TF. 2200
1010.

Operating and Maintenance Handbook

MARCONI INSTRUMENTS LIMITED. ENGLAND

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OSCILLOSCOPE
TYPE TF 2200
VOL. I

MP MASTER
MA23636

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MARCONI
INSTRUMENTS

EB 2200
1 - 8/62

OPERATING INSTRUCTIONS

for

OSCILLOSCOPE

TYPE TF 2200

Marconi Instruments Limited, St. Albans, Hertfordshire, England.

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CONTENTS

Note : Certain Sections included in this list of Contents are marked with asterisks. These sections refer to individual Plug-In Units which are Optional Accessories.

The relevant pages of text are included, or omitted, according to whether or not a particular plug-in unit is supplied with the instrument. The page numbering is interrupted at these points and forms a continuous sequence only when all the Plug-In Units are purchased.

In the event of a Plug-In Unit being ordered separately, the appropriate pages are supplied for inclusion in this handbook.

Vol. I

Section		Page
	SCHEDULE OF PARTS SUPPLIED	xi
*	Single Trace Unit Type TM 6455	xiii
*	Dual Trace Unit Type TM 6456	xv
*	TV-Differential Unit Type TM 6457	xvii
	DATA SUMMARY	xix
	Overall performance with :-	
	Single Trace Unit Type TM 6455	xix
	Dual Trace Unit Type TM 6456	xxi
	TV-Differential Unit Type TM 6457	xxi
	Y AMPLIFIER)	xxii
	X AMPLIFIER)	xxiii
	SWEEP GENERATOR) Main Instrument	xxiii
	POWER SUPPLY)	xxvii
	DIMENSIONS & WEIGHT)	xxvii

CONTENTS (continued)

Section		Page
1	INTRODUCTION	1
1.1	PLUG-IN PRE-AMPLIFIERS	1
1.1.1	Single-Trace Unit Type TM 6455	2
1.1.2	Dual-Trace Unit Type TM 6456	2
1.1.3	TV-Differential Unit Type TM 6457	2
1.2	DELAYED SWEEP	3
1.3	DISPLAY FEATURES	3
2	OPERATION	4
2.1	INSTALLATION	4
2.2	SWITCHING ON	4
2.3	FIRST TIME OPERATION	5
2.4	DELAYING TIME BASE	8
2.4.1	DELAY function	8
2.4.2	GATED function	9
2.4.3	MULTI TRIG function	10
2.4.4	MULTI TRIG for Sine Squared Pulse and Bar display	11
2.4.5	Displaying composite video waveforms	12
2.4.6	Displaying non-composite video waveforms	13
2.5	PHOTOGRAPHIC TECHNIQUES	14
2.5.1	Graticule and Filter	15
2.5.2	Single-Shot operation	15
2.6	CONTROLS	16
2.6.1	C.R.T. Controls	17
2.6.2	Y Amplifier Controls	17
*2.6.3	Single Trace Unit Controls	21
*2.6.4	Dual Trace Unit Controls	23
*2.6.5	TV-Differential Unit Controls	27
2.6.6	X Amplifier Controls	31
2.6.7	Main Time Base (A) Controls	35
2.6.8	Delaying Time Base (B) Controls	36
2.6.9	Trigger-Circuit Controls	37
2.6.10	Miscellaneous Controls	41
2.7	DIRECT CONNECTION TO Y PLATES	43
2.8	USE OF ACCESSORIES	44

CONTENTS (continued)

Section		Page
3	TECHNICAL DESCRIPTION	46
*3.1	SINGLE-TRACE UNIT	47
*3.1.1	Synopsis	47
*3.1.2	Circuit Analysis	47
*3.2	DUAL-TRACE UNIT	49
*3.2.1	Synopsis	49
*3.2.2	Circuit Analysis	50
*3.2.2.1	Gate Drive Circuit	51
*3.3	TV-DIFFERENTIAL UNIT	53
*3.3.1	Synopsis	53
*3.3.2	Circuit Analysis	54
3.4	Y AMPLIFIER	59
3.4.1	Synopsis	59
3.4.2	Circuit Analysis	59
3.5	TRIGGER CIRCUIT	61
3.5.1	Synopsis	61
3.5.2	Circuit Analysis	62
3.6	DELAYING TIME BASE	66
3.6.1	Synopsis	66
3.6.2	Circuit Analysis.	67
3.6.2.1	Input Schmitt Operation.	67
3.6.2.2	Miller Circuit	70
3.6.2.3	Delay Pick Off	70
3.7	FUNCTION CIRCUIT	71
3.7.1	NORMAL (A)	71
3.7.2	NORMAL (A) but with S402 in the ARM posn	72
3.7.3	NORMAL (A) but with S402 in the FIRE posn	72
3.7.4	DELAY (B)+(A) and DELAY (A)	73
3.7.5	GATED (B)+(A) and GATED (A)	73
3.7.6	MULTI TRIG (B)+(A) and MULTI TRIG (A)	74
3.7.7	EXT	75
3.7.8	General	75
3.8	MAIN TIME BASE	76
3.8.1	Comparison with Delaying Time Base.	76
3.9	X AMPLIFIER	79
3.9.1	Synopsis	79
3.9.2	Circuit Analysis	79
3.10	E.H.T. UNIT	80
3.10.1	Synopsis	80
3.10.2	Circuit Analysis	81
3.10.2.1	Cathode-Ray Tube Operating Conditions	82

CONTENTS (continued)

Section		Page
3	TECHNICAL DESCRIPTION (continued)	
3.11	POWER SUPPLY	83
3.11.1	Synopsis	83
3.11.2	Circuit Analysis	83
3.11.2.1	-150 volt line	83
3.11.2.2	+100 volt line	84
3.11.2.3	+250 volt line	85
3.11.2.4	+350 volt line	85
3.11.2.5	+500 volt line	85
3.11.2.6	-6.3 volt line	85
3.11.2.7	L.T. Supplies	86
3.11.2.8	CAL waveform generator	86
3.11.2.9	Thermal cut-out	87
3.11.2.10	Miscellaneous details	87
3.12	SWITCH ATTENUATOR	87
3.12.1	Synopsis	87
3.12.2	Circuit Analysis	88
4	MAINTENANCE	91
4.1	GENERAL	91
4.2	CLEANING THE AIR FILTER	91
4.3	REMOVAL OF COVERS - ACCESS TO COMPONENTS	93
4.3.1	Time Base Removal	93
4.3.2	E.H.T. Unit Removal	94
4.3.3	Rear Panel Removal	94
4.4	REPLACEMENT OF FUSES	95
4.5	MAINS INPUT ADJUSTMENTS	95
4.6	WORKING VOLTAGES	96
4.7	WIRING COLOUR CODE	97
4.8	REPLACEMENT OF C.R.T., VALVES AND SEMICONDUCTORS	98
4.8.1	C.R.T. Removal and Adjustment	98
4.8.2	Valve Replacement	99
4.8.3	Replacement of Transistors	100
4.8.4	Replacement of Semiconductor Diodes	100

CONTENTS (continued)

Section		Page
4	MAINTENANCE (continued)	
4.9	ADJUSTMENT OF PRESET COMPONENTS	101
*4.9.1	Single Trace Unit	103
*4.9.1.1	Adjustment Procedure	103
*4.9.1.2	Inductors	104
*4.9.2	Dual Trace Unit	105
*4.9.2.1	Adjustment Procedure	105
*4.9.2.2	Inductors	107
*4.9.3	TV-Differential Unit	109
*4.9.3.1	Adjustment Procedure	109
*4.9.3.2	Inductors	111
4.9.4	Y Amplifier	113
4.9.4.1	Adjustment Procedure	113
4.9.4.2	Sync Pick-Off Adjustments	114
4.9.4.3	Y Amplifier Inductors	115
4.9.4.4	Delay Line Adjustment	116
4.9.5	Trigger Circuit	116
4.9.5.1	Adjustment Procedure	117
4.9.6	Delaying Time Base	117
4.9.6.1	Adjustment Procedure	117
4.9.7	Function Circuit	118
4.9.8	Main Time Base	119
4.9.8.1	Adjustment Procedure	119
4.9.9	X Amplifier	120
4.9.9.1	Adjustment Procedure	120
4.9.9.2	X Amplifier Inductors	121
4.9.10	E.H.T. Unit and Display	121
4.9.10.1	Adjustment Procedure	122
4.9.11	Power Supply	122
4.9.11.1	Adjustment Procedure	123

CONTENTS (continued)

APPENDICES

FRONT PANEL CONTROLS (Printed Drawing No. TLB 38723
Follows page 42

INPUT SCHMITT CIRCUIT ANALYSIS Drawing No. XD 38275
Follows page 70

ANALYSIS OF SWITCH ATTENUATOR RANGES
Drawing No. XD 38472 Follows page 90

SUPPLY VOLTAGE PLUG SETTINGS (Printed Drawing)
Follows page 96

RECOMMENDED METHODS OF SERVICING PRINTED WIRING BOARDS (Printed Appendix 2, EBA2)
Follows page 100

Vol. II

DRAWINGS — Drawing No.

BLOCK SCHEMATIC DIAGRAM OF OSCILLOSCOPE TYPE TF 2200 (Sheet 1)

*BLOCK SCHEMATIC DIAGRAM OF SINGLE-TRACE UNIT TYPE TM 6455 (Sheet 2)

*BLOCK SCHEMATIC DIAGRAM OF DUAL-TRACE UNIT TYPE TM 6456 (Sheet 3)

*BLOCK SCHEMATIC DIAGRAM OF TV-DIFFERENTIAL UNIT TYPE TM 6457 (Sheet 4) — XD 37330

*PLUG-IN SINGLE-TRACE PRE-AMPLIFIER (Circuit Diagram and 3-sheet Component List) — XD 37841

*PLUG-IN DUAL-TRACE PRE-AMPLIFIER (Circuit Diagram and 5-sheet Component List) — XD 34650

*PLUG-IN TV-DIFFERENTIAL UNIT (Circuit Diagram and 6-sheet Component List) — XD 38947

SWITCH ATTENUATOR (Circuit Diagram and 2-sheet Component List) — XD 34658

Y AMPLIFIER AND DELAY LINE (2-sheet Circuit Diagram and 4-sheet Component List) — XD 37331

CONTENTS (continued)

DRAWINGS (continued)	Drawing No.
TRIGGER CIRCUIT (Circuit Diagram and 3-sheet Component List)	XD 37332
DELAYING TIME BASE AND RANGE SWITCH (2-sheet Circuit Diagram and 4-sheet Component List)	XD 37333
FUNCTION CIRCUIT (Circuit Diagram and 2-sheet Component List)	XD 37334
MAIN TIME BASE and RANGE SWITCH (2-sheet Circuit Diagram and 4-sheet Component List)	XD 37335
X AMPLIFIER (Circuit Diagram and 2-sheet Component List)	XD 37336
E.H.T. UNIT AND DISPLAY (Circuit Diagram and 2-sheet Component List)	XD 37337
POWER SUPPLY (Circuit Diagram and 5-sheet Component List)	XD 37338
SOCKET CONNECTION DIAGRAM (Circuit Diagram and 2-sheet Component List)	XD 37339

SCHEDULE OF PARTS SUPPLIED

The complete equipment comprises the following items :-

1. One Oscilloscope Type TF 2200 complete with valves, etc., as under :-

Valves:	Fourteen:	Type ECF804, Frame-Grid Triode Pentodes.
	Ten:	Type ECC88 (6DJ8), Double Triodes.
	Two:	Type E55L, Frame-Grid Pentodes.
	Two:	Type EB91 (6AL5), Double Diodes.
	One:	Type ECC81 (12AT7), Double Triode.
	Three:	Type ECC83 (12AX7), Double Triodes.
	One:	Type 6AU6, Pentode.
	Three:	Type EL822(6CH6), Pentodes.
	Three:	Type 6080, Double Triodes.
	Two:	Type 85A2, Voltage Reference Tubes.
	Two:	Type Q/U37, E.H.T. Rectifiers.
	One:	Type VLS631, Thermal Delay Switch.
Cathode-Ray Tube:	One:	Type SE5D/CC, 5-inch diameter, P2 phosphor (green). Long-persistence or other phosphors can be supplied to special order.
Semiconductors:		
	Twenty:	Type 1N540, Silicon Rectifiers.
	Four:	Type OA202, Silicon Diodes.
	One:	Type Z2A39F, Zener Diode.
	One:	Type GET102 (OC83), Germanium p-n-p transistor.
	One:	Type CDT1349A (2N2062), Germanium p-n-p transistor.
	One:	Type CTP1508 (2N1553), Germanium p-n-p transistor.
	One:	Type OC200 (2N330A), Silicon p-n-p transistor.
	Seven:	Type OA85, Germanium Point-Contact Diodes.
	One:	Type 2DS500 (Bradley) L.T. Rectifier.
EITHER	Two:	Type HSC4 (Hughes), E.H.T. Rectifiers.
OR	Eight:	Type DD058 (Bradley), E.H.T. Rectifiers.
	Two:	Type ZC22 (Brush), Zener Diodes.

SCHEDULE OF PARTS SUPPLIED (continued)

Fuses:		
EITHER	Two:	5-Ampere Cartridge Fuses (200- to 250-volt supplies).
OR	Two:	10-Ampere Cartridge Fuses (100- to 130-volt supplies).
	Four:	500 mA Cartridge Fuses.
	One:	5-Ampere Cartridge Fuse.
Lamps:	Two:	Graticule Lamps, Marconi Type TB 37140.
	Three:	Type 33CL, 65-volt, Neon Indicators.
	One:	Type 8-volt, 0.15-ampere, L.E.S. Pilot Lamp.

2. One Coaxial Free Plug Type 83, for trigger input connection.

3. One C.R.T. Graticule, Type TC 36851; ruled in centimetre squares, for time and voltage measurement.

4. One complete set of spare cartridge fuses.

5. One Instruction Book No. EB 2200 - with loose-leaf sections to cover the appropriate plug-in Pre-amplifier Units. (Two Volumes.)

ACCESSORIES AVAILABLE

The following items are optional accessories, supplied only if specially ordered :-

5. Single Trace Unit, TM 6455.

6. Dual Trace Unit, TM 6456.

7. TV-Differential Unit, TM 6457.

Further details of the above plug-in Pre-amplifier Units, including details of valves, semiconductors, etc., are given at the end of this Section - depending upon the units supplied.

SCHEDULE OF PARTS SUPPLIED (continued)

ACCESSORIES AVAILABLE (continued)

8. Probe Lead, TM 5269: Comprises a low-capacitance, low-loss coaxial cable assembly, 30 inches long. One end is terminated with a Type 83 plug; the other end fitted with a test prod and earth clip.

9. Probe Unit, TM 5793/1: Increases the Y-input impedance to 10 MΩ and introduced an attenuation factor of x10. The shunt input capacitance is approximately 7 pF. Supplied complete with attached lead 30 inches long; the free end is fitted with a Type 83 plug. Probe tip accommodates either a 3-inch test prod or an insulated crocodile clip, both of which are supplied with the probe.

10. Cathode-Follower Probe, TM 6942: Increases Y-input impedance to approximately 10 MΩ with 8 pF in shunt. The probe accepts inputs up to 3 volts p-p at frequencies from 4 c/s to 30 Mc/s; it attenuates the input signal by 6 dB. Supplied complete with test prod and connecting leads, the probe derives its power supplies from the PROBE POWER socket on the oscilloscope.

11. Extension Cable, TM 6943: 24-way, 18 inches long; for use when servicing and adjusting the Plug-In Units.

12. C.R.T. Graticule, TC 37574: For the evaluation of K-factors from 0.01 to 0.05.

13. Camera Mount Assembly, TM 7279: When substituted for the standard 5 5/8" dia. viewing hood, this assembly permits the Tektronix range of oscilloscope cameras to be used.

14. Visor, TD 39583: Moulded from best quality grey rubber, the visor is anatomically designed to exclude all stray light.

DATA SUMMARY

for

OSCILLOSCOPE

TYPE TF 2200

Overall performance with :-

SINGLE TRACE UNIT
TYPE TM 6455 :

Bandwidth :
TRANSIENT (with Gaussian roll off and overshoot less than 1%):
x1 SENSITIVITY: -3 dB at 30 Mc/s.
x5 SENSITIVITY: -3 dB at 20 Mc/s.
WIDEBAND (with overshoot):
x1 SENSITIVITY: -3 dB at 36 Mc/s.
x5 SENSITIVITY: -3 dB at 28 Mc/s.

Risetime: 12 nsec for overshoot of less than 1%, at x1 SENSITIVITY.

Sensitivity: Ten switched ranges in 1-2-5 sequence from 50 mV/cm to 50 volts/cm. In addition, an uncalibrated gain control provides variable adjustment over a nominal 2.5:1 range on each step. A x5 increase in sensitivity, within the band d.c. to 20 Mc/s, extends the maximum sensitivity to 10 mV/cm when required. Accuracy of switched attenuator ratios: 2%.

AC/DC switch: In the AC position response is -3 dB at 2 c/s.

Input Selector: Selects either input socket; central position disconnects the Y amplifier from both sockets and earths the input to the amplifier.

Input Impedance: 1 MΩ with 30 pF in shunt at all sensitivities. Using Probe Type TM 5793/1 (see ACCESSORIES AVAILABLE), impedance is 10 MΩ with 7 pF in shunt.

DATA SUMMARY (continued)

Overall Performance with :-

DUAL TRACE UNIT
TYPE TM 6456:

Bandwidth:
TRANSIENT (with Gaussian roll off and overshoot less than 1%):
-3 dB at 25 Mc/s.
WIDEBAND (with overshoot):
-3 dB at 33 Mc/s.

Risetime: 14 nsec for overshoot of less than 1%.

Sensitivity: Separate attenuators for each channel have ten calibrated steps in 1-2-5 sequence from 50 mV/cm to 50 volts/cm. In addition, uncalibrated gain controls provide for continuously-variable adjustment over a nominal 2.5:1 on each step of the attenuators. Accuracy of switched attenuator ratios: 2%.

Y Shift: Separate Y-shift controls are provided for each channel.

AC/DC Switches: In the AC positions response is -3 dB at 2 c/s.

Phase Shift: Time difference between channels less than 1 nsec.

Input Impedance: 1 MΩ with 27 pF in shunt at all sensitivities. Using Probe Type TM 5793/1 (see ACCESSORIES AVAILABLE), impedance is 10 MΩ with 7 pF in shunt.

Polarity Reversal: To simplify comparison of signals 180° out of phase, the polarity of either channel can be inverted.

Display Selection: Five position selection giving:-

ALT.	Channels A and B displayed on alternate time base sweeps.
A	Channel A only.
A+B	Algebraic sum of both input channels.
B	Channel B only.
CHOP	Chopped display of both channels at 500 kc/s switching rate.

DATA SUMMARY (continued)

PROVISIONAL

Overall performance with :-

TV-DIFFERENTIAL UNIT TYPE TM 6457 :

Bandwidth:
TRANSIENT (with Gaussian roll off and overshoot less than 1%):
-3 dB at 20 Mc/s.
WIDEBAND (with overshoot):
-3 dB at 28 Mc/s.

Risetime: 18 nsec for overshoot of less than 1%, at x1 SENSITIVITY.

Sensitivity: Independent attenuators for each channel have ten calibrated steps in 1-2-5 sequence from 50 mV/cm to 50 volts/cm. A common variable attenuator, affecting the gain of both channels simultaneously, makes the adjustment continuously variable over a nominal 2.5:1 on each step of the attenuators. Accuracy of switched attenuator ratios: 2%.

Additional high gain positions of x10 and x50 introduce further a.c. amplification over the following frequency ranges :-
x10 : 4 c/s to 8 Mc/s (5 mV/cm).
x50 : 4 c/s to 800 kc/s (1 mV/cm).

Backing-Off: D.C. potentials in the range ±10 volts may be backed off on the 50 mV/cm range. Porportionally greater potentials may be backed-off at higher attenuator settings.

Common-Mode Rejection: When correctly balanced, better than 40 dB at any attenuator setting, at frequencies below 10 Mc/s.

Clamp: The input waveform may be clamped at a level determined by the setting of the TRIGGER LEVEL control.

DATA SUMMARY (continued)

TV-DIFFERENTIAL UNIT
TYPE TM 6457: (continued)

AC/DC switches: In the AC positions response is -3 dB at 2 c/s.

Input Impedance: 1 MΩ with 30 pF in shunt at all sensitivities. Using Probe Type TM 5793/1(seeACCESSORIES AVAILABLE), impedance is 10 MΩ with 7 pF in shunt.

Performance of Main Instrument :

Y AMPLIFIER

AMPLITUDE MEASUREMENT:	By calibrated Y-shift potentiometer. Accuracy: x1: ±5% of full-scale dial reading. x10: ±2% of full-scale dial reading. By calibrated graticule. Accuracy : ±3% of 5 cm display.
INPUT SELECTION:	See DATA SUMMARY for individual plug-in Units.
INPUT IMPEDANCE:	See DATA SUMMARY for individual plug-in Units.
SIGNAL DELAY:	A signal delay of 0.28 μsec is introduced by a balanced lumped-constant delay line. Permits measurement of the leading edge of the waveform that triggers the sweep.
HUM & NOISE LEVEL:	Less than 0.5 mm width at 50 mV/cm sensitivity.
Z MODULATION:	Input Requirements: Up to 3 volts p-p depending upon frequency. 50 c/s to 5 Mc/s. Input Impedance: 470 kΩ shunted by 50 pF.

DATA SUMMARY (continued)

X AMPLIFIER

BANDWIDTH:	2 c/s to 2.4 Mc/s (-3 dB).
EXPANSION:	Continuously variable from x1 to more than x5.
SENSITIVITY:	Approximately 3.5 V/cm at minimum expansion; increases to at least 750 mV/cm at maximum.
EXTERNAL INPUT:	Impedance: 470 kΩ, a.c. coupled with 0.25 μF capacitor.
X SHIFT:	At minimum expansion, the sweep width is approximately 10.5 cm, and the display can be moved through more than 2 screen diameters

SWEEP GENERATOR

Two time bases are available :-

MAIN TIME BASE (A):

Sweep Velocity: Twenty four switched ranges in 1-2-5 sequence covering the range 2 sec/cm to 50 nsec/cm at minimum X-expansion; maximum expansion increases fastest sweep to faster than 10 nsec/cm.

Time Measurement: By calibrated X-shift potentiometer with scales for each sweep range.
Accuracy: x1; ±5% of full-scale dial reading.
x10; ±2% of full-scale dial reading.
By calibrated graticule. Accuracy : ±3% of 10 cm display.

Output Sawtooth: Available from an isolating cathode follower at a front panel terminal. Sawtooth is positive-going between the levels +5 to +65 volts.

Trace Bright-up: Available from an isolating cathode follower at a front panel terminal. Output voltages are :-
-25 volts during waiting time.
+ 5 volts during delay sweep.
+15 volts during main sweep.

DATA SUMMARY (continued)

SWEEP GENERATOR (continued)

DELAYING TIME BASE (B):

Sweep Velocity: Six switched ranges in 1-10-100 sequence covering the range 100 msec/cm to 1 μsec/cm at maximum velocity setting. Minimum velocity setting decreases the slowest sweep to approximately 0.5 sec/cm.

Time Measurement: By calibrated 10-turn helipot which determines the point on the run-down at which pick off occurs. Accuracy: ±2% of full scale, ±0.5 μsec, whichever is the greater.
Velocity Ratio: Approximately 5:1.

TRIGGER FACILITIES:

Input Modes: Six-position selector switch for EXT (B), TV, DC, AC, AUTO, and HF; a further switch selects input from internal, external, or supply-frequency sources. Single-Shot facilities are also provided.

Internal Triggering: 2 mm p-p of sinusoidal trace display will give a triggered time base over the following frequency ranges :-

AC and AUTO: 20 c/s to 1 Mc/s.
DC : d.c. to 1 Mc/s.

10 mm p-p trace amplitude extends the trigger upper limit to at least 5 Mc/s.

TV position gives differentiated field lock on any 405-, 525-, or 625-line, positive or negative, 50 or 60 c/s, television waveform - provided the sync pulse amplitude is 3 mm p-p or more. This position is a.c. coupled and d.c. restored to maintain satisfactory field lock under adverse conditions. The Delay Time Base will display either odd or even fields, changed by pressing the BEAM LOCATE button.

HF enables synchronized time-base operation from 2 Mc/s upwards. 2 mm p-p display is necessary for frequencies up to 25 Mc/s, increasing to 10 mm at 30 Mc/s.

DATA SUMMARY (continued)

SWEEP GENERATOR (continued)

TRIGGER FACILITIES (continued)

In the absence of any signal for triggering purposes, the time base will free run at approximately 50 c/s in the AUTO position.

External Triggering: All the above figures apply if 0.5 volt p-p is substituted for 2 mm of trace.

Input Impedance :-

TV, DC, AC, and AUTO:	1 MΩ shunted by 25 pF.
EXT(B) (Delaying T/B) :	10 kΩ a.c. coupled.
HF :	Greater than 1 kΩ a.c. coupled.

∿ position permits internal supply-frequency triggering.

Trigger Level control windows two screen diameters on INTERNAL, and nominally 20 V on EXTERNAL. On AUTO this control is rendered inoperative and on HF it acts as a synchronizing control.

FUNCTION SWITCH: A front-panel control selects any one of the following sweep conditions :-

NORMAL: Main Time Base is triggered by signal and provides horizontal deflection.

Additionally; 3-position selector having NORMAL, ARM, and FIRE positions, permits single-shot operation.

DELAY: Delay Time Base is triggered by signal and, after an adjustable delay, triggers Main Time Base.

DATA SUMMARY (continued)

SWEEP GENERATOR (continued)

FUNCTION SWITCH (continued)

(B)+(A): Delaying Time Base provides horizontal deflection. A bright portion of the trace indicates the duration of the Main Time Base.

(A): Horizontal deflection is provided by the Main Time Base.

GATED: Main Time Base is triggered by signal, via a gating circuit. Gate is opened after an adjustable delay, by the Delaying Time Base; it closes again after one sweep of the Main Time Base.

(B)+(A): Delaying Time Base provides horizontal deflection. A bright portion of the trace indicates the duration of the Main Time Base.

(A): Horizontal deflection is provided by the Main Time Base.

MULTI-TRIG: Delaying Time Base is triggered by signal. After an adjustable delay, a gating circuit is opened and, simultaneously, the Main Time Base is triggered. The gate remains open after the first sweep of the Main Time Base, permitting subsequent sweeps to be triggered by external signals until the Delaying Time Base completes its sweep and closes the gate.

DATA SUMMARY (continued)

SWEEP GENERATOR (continued)

FUNCTION SWITCH (continued)

(B)+(A): Delaying Time Base provides horizontal deflection and bright portions of trace indicate Main Time Base sweep periods.

(A): Horizontal deflection is provided by the Main Time Base.

EXT T B : Horizontal deflection is provided by an external signal which is amplified by the X amplifier.

EXTERNAL TRIGGERING OF DELAYING TIME BASE: Under most normal circumstances the Delaying Time Base is triggered internally. It may, however, be triggered independently by switching to EXT (B) and applying several volts of fast negative-going triggering waveform to the EXT (B) socket.

POWER SUPPLY: 200 to 250 volts or 100 to 130 volts, 50 to 60 c/s ; 600 watts (with Dual-Trace Unit). For details of operation from other supply frequencies and voltages, consult Marconi Instruments Ltd.

DIMENSIONS & WEIGHT:

Height	Width	Depth	Weight
17½ in (44.5 cm)	13 in (33 cm)	27 1/4 in (70 cm)	73 lb (33 kg)

1 INTRODUCTION

The TF 2200 is a top grade laboratory oscilloscope for the precision measurement of high speed phenomena. The triggered X deflection can be accurately delayed, enabling detailed observation, photography, and measurement of selected portions of complex waveforms. Such displays are rendered possible by the fast rise time combined with wide sweep-speed range of this oscilloscope. A full 5-cm display is available throughout the frequency range and the 10 kV post deflection accelerating voltage ensures a high writing speed of adequate brilliance.

In addition to its many uses as a general-purpose high-quality oscilloscope, the TF 2200 has all the additional advantages of a delayed sweep, so that any portion of a complex waveform may be greatly enlarged and presented as a jitter-free image for precise analysis. When the TF 2200 is being used in this manner, as a line-strobe waveform monitor, the bright-up pulse may be applied to an associated picture monitor on whose screen the line, or lines, under examination will be clearly indicated.

Single-shot operation can be used for photographing 'once only' phenomena, or for photographing spurious signals in a recurrent waveform.

1.1 PLUG-IN PRE-AMPLIFIERS

By using the appropriate pre-amplifier unit the TF 2200 may be converted from a single- to a dual-trace instrument, or to an oscilloscope with television and differential input facilities.

Operating instructions and technical details of the appropriate preamplifier unit(s) for your instrument are included in this handbook. Should an additional pre-amplifier unit be obtained at a later date, the appropriate handbook pages will be supplied, for inclusion in this handbook. To allow room for these pre-amplifier sections, the page numbering will have discontinuities unless <u>all</u> the pre-amplifier units are obtained.

1.1.1 Single Trace Unit Type TM 6455 provides a Y-amplifier passband of d.c. to 30 Mc/s, with a risetime of 12 nsec, and an overshoot of less than 1%. When overshoot is permissible, the Y-amplifier may be switched for wide-band operation, giving a pass-band of d.c. to 36 Mc/s for sinusoidal displays. Under both these conditions the maximum deflection sensitivity is 50 mV/cm. A x5 increase in sensitivity may be obtained over the frequency range d.c. to 20 Mc/s, giving a maximum input sensitivity of 10 mV/cm.

1.1.2 Dual Trace Unit Type TM 6456 provides electronic beam switching which enables two independent signals to be displayed, either on alternate sweeps or chopped at 500 kc/s repetition rate- the latter has transient blanking internally applied during the change-over period to produce a clearly defined display. This unit provides a Y-amplifier passband of d.c. to 25 Mc/s, with a risetime of 14 nsec and an overshoot of less than 1%. Increased bandwidth extending to 33 Mc/s may be obtained by switch selection, for the display of sinusoidal waveforms, when overshoot is permissible. Maximum deflection sensitivity is 50 mV/cm for both input channels.

1.1.3 TV-Differential Unit Type TM 6457. If a single input waveform is applied to either of the input sockets, it can be displayed by the oscilloscope in the normal manner; application of separate waveforms to the two input sockets enables their differential voltage waveform to be displayed. Unbalanced d.c. between the two input channels may be backed-off within the limits ±10 volts on the 50 mV/cm range. Proportionally greater potentials may be backed off at higher attenuator settings. Clamping facilities are provided for TV waveform measurements, the clamping level being adjustable by means of the TRIGGER LEVEL control. When the unit has been correctly balanced, common-mode rejection between the two channels is better than 40 dB at frequencies less than 10 Mc/s. Maximum deflection sensitivity is 50 mV/cm, and both inputs have a pass-band of d.c. to 20 Mc/s with a rise time of 18 nsec for an overshoot of less than 1%. When overshoot can be tolerated, the Y amplifier may be switched for wide-band operation, giving a passband of d.c. to 28 Mc/s.

1.1.3 (continued)

Additional high-gain positions of x10 and x50 introduce further a.c. amplification over the following frequency ranges :-

x10 : 4 c/s to 8 Mc/s

x50 : 4 c/s to 800 kc/s

1.2 DELAYED SWEEP

Two basic modes of operation are provided; a conventional delayed sweep in which a delaying time base receives a trigger signal and, in turn, triggers the main time base after an adjustable delay - or a gated delayed sweep in which the main time base is triggered via a gate - this gate is opened by the delaying time base at the appropriate point on its run down. Time jitter, at maximum delay, is less than 1 part in 10^4 when the conventional delayed sweep is used. With gated operation the main time base is triggered by the actual signal under observation, resulting in a steady display under all conditions, even when the triggering signal is itself jittering. Progressive circuit design has eliminated the necessity for a STABILITY control, and relaible triggering is obtained by using one control only - TRIGGER LEVEL.

1.3 DISPLAY FEATURES

To enable you to take full advantage of the extremely slow sweep speeds of which this oscilloscope is capable, special long-persistence tubes can be supplied to fit in the place of the normal type. The viewing hood round the screen of the tube is of conventional size to permit the attachment of a standard 5 5/8" clamp-on camera mounting. To give immediate access to the tube screen, the viewing hood is mounted on hinges, and fitted with quick-release fasteners.

Alternative camera-mounting arrangements are available if required.

2 OPERATION

2.1 INSTALLATION

Unless otherwise specified the Oscilloscope is normally dispatched with its valves and cathode-ray tube in position and with its mains input circuit adjusted ready for immediate use with 240-volt a.c. mains supplies. The instrument can, however, be adjusted to operate from any 50- to 60- c/s supply in the ranges 100 to 130 volts and 200 to 250 volts. To check or alter the settings of the mains transformer tappings, you should refer to Section 4.5, MAINS INPUT ADJUSTMENTS. Before operating the TF 2200 from supply frequencies or voltages outside the above ranges, consult Marconi Instruments Ltd.

The power supply cable is colour coded as follows:-

RED:	Live (phase))	
BLACK:	Neutral)	Supply lines
GREEN:	Earth/Ground	(Chassis connection)

Care should be taken to see that a clearance of at least two inches exists behind the instrument to allow sufficient air intake for the ventilating fan; similarly, a few inches should be allowed on either side of the oscilloscope; overheating may otherwise result. The air intake incoporates a filter which should be cleaned periodically as described in Section 4.2.

A hinged support rail is provided underneath the front of the Oscilloscope to enable it to be tilted to a convenient viewing angle.

2.2 SWITCHING ON

Before switching on, ensure that the instrument is correctly adjusted for the particular mains supply to which it is to be connected and that sufficient clearance is provided behind the fan intake. Then proceed as follows:-

(1) Connect the mains lead to a suitable mains supply point.

(2) Switch ON the SUPPLY (bottom right-hand side). A 30-second thermal delay switch is incorporated to prevent h.t. being applied before the valves have had sufficient time to warm up.

2.3 FIRST TIME OPERATION

The following procedure has been devised to assist you when using the Oscilloscope for the first time. It is confined to one simple application, namely the display of an audio frequency sine wave, but will help you to become familiar with the basic operation of the controls. The procedure is equally applicable to any of the Plug-In Units.

When this simple procedure has been carried out, the detailed information given in Section 2.4, should enable the Oscilloscope to be used for any of the more advanced applications of which it is capable.

The index figures used in the following text refer to the physical layout of the controls on the front panel (see Drawing No. TLB 38728 following page 42).

(1) Put the SUPPLY[25] switch to ON. Then, while waiting for the instrument to warm up, set the following controls as indicated, in order to obtain a time-base trace.

X SHIFT[17]	Mid-position
EXPANSION[16]	Fully counter-clockwise to TIME/CM CALIBRATED mark.
Y SHIFT (on Plug-In)	Mid-position
VOLTS SCALE[4]	Clockwise (0 on the dial)
TIME SCALE[14]	Clockwise (0 on the dial)
FUNCTION switch[15]	(A) Normal
MAIN TIME BASE RANGE[18]	10 msec
TRIGGER MODE[21]	AUTO
NORMAL-ARM-FIRE[20]	NORMAL

2.3 (continued)

After a delay of some 30 seconds from switching ON a slight click will denote closure of the h.t. relay and a trace should appear.

(2) Adjust the BRILLIANCE[8] control to obtain the required trace intensity, and centralize the trace by means of the X SHIFT[17] and Y SHIFT (on Plug-In) controls. If no trace appears, press the BEAM LOCATE[12] push-button, and adjust the appropriate shift controls. Adjust the FOCUS[2] and ASTIG[1] controls for a uniformly sharp display. Also adjust the GRATICULE[7] control to illuminate the c.r.t. graticule, if required.

(3) Now adjust the remaining controls, as follows, to prepare for the display of a 1000-c/s, 1-volt sinewave.

TRIGGER +-[22]	+
∿-INT-EXT[24]	INT
VOLTS RANGE (on Plug-In)	0.2 volts/cm
INPUT SELECTOR (on Plug-In)	Input A
AC/DC switch (on Plug-In)	AC
Y GAIN (on Plug-In)	Fully clockwise to VOLTS/CM CALIBRATED mark
Y GAIN switch (Single Trace and TV-Differential Units only)	x1

(4) Apply a sinewave signal of about 1 kc/s, 1 volt p-p to INPUT A. Adjust the VOLTS RANGE switch (on Plug-In) to alter the trace amplitude in calibrated steps, or the Y GAIN control for uncalibrated variations. Similarly, adjust

2.3 (continued)

the MAIN TIME BASE RANGE[18] switch to alter the number of cycles in the display in calibrated steps, or the EXPANSION[16] for uncalibrated variations. With the Y GAIN and EXPANSION[16] controls in their CALIBRATED positions, both amplitude and time may be measured by using the centimetre squares on the graticule; the X SHIFT[17] and Y SHIFT (on Plug-In) controls may be used to position the display in relation to the graticule.

It will be observed that triggering of the time base occurs during the positive-going part of the waveform. Negative-going triggering may be obtained by reversing the TRIGGER +-[22] switch.

In the above procedure the TRIGGER MODE[21] switch is set to AUTO and in this position the TRIGGER LEVEL[23] control is rendered inoperative. To familiarize yourself with the use of the TRIGGER LEVEL[23] control, continue as follows :-

(a) Set the TRIGGER MODE[21] switch to AC and centre the TRIGGER LEVEL[23] control.

(b) Move the TRIGGER LEVEL[23] control each way and observe the point on the waveform at which triggering occurs - at the extreme left hand edge of the trace.

(c) Set the TRIGGER +-[22] switch to - and repeat step (b).

The TRIGGER LEVEL[23] control is only used in conjunction with the TV, DC, and AC positions of the TRIGGER MODE[21] switch. In the AUTO position it is inoperative, and in the HF position it functions as a synchronizing control at frequencies above about 2 Mc/s.

2.4 DELAYING TIME BASE

The following procedure is not intended as the normal step-by-step procedure for using the delaying time base, and should be regarded as a guide to those who have not used a delaying time base before. After following and understanding the principles of operation described below, you will rapidly develop your own 'short cut' procedures which, although simple and quick, are quite mystifying to those who have not grasped the underlying principles. A complex pulse waveform is particularly suitable for this exercise.

2.4.1 DELAY function

(1) Display a waveform as already described in Section 2.3, with the FUNCTION[15] switch set to (A) NORMAL and with the TRIGGER MODE[21] switch set to AC or DC as appropriate. Adjust the TRIGGER LEVEL[23] control and TRIGGER +-[22] switch to obtain triggering on the required part of the waveform.

(2) Turn the DELAY TIME MULTIPLIER[9] fully counter-clockwise to 0 and set the DELAY TIME[10] switch, to the same setting as the main time base RANGE[18] switch. (This may mean altering the setting of the latter switch.) Turn the VELOCITY[11] control fully clockwise to its CALIBRATED position.

(3) While watching the display, turn the FUNCTION[15] switch to DELAY (B) +(A). Horizontal deflection is now provided by the delaying time base and, apart from the possibility of the trace being less bright, the display should be the same as before.

(4) If the brightness in (3) above is less than before, advance the DELAY TIME MULTIPLIER[9] in a clockwise direction until the whole display suddenly brightens. This brightening is due to the main time base which has been adjusted in (2) above to have the same duration as the delaying time base run down.

2.4.1 (continued)

(5) Set the main time base RANGE[18] switch to progressively faster ranges and note that the left hand part of the trace remains bright and that the bright area diminishes in width as the main time base duration gets shorter.

(6) With the main time base RANGE[18] switch set to a suitable range (faster than the DELAY TIME[10] range) adjust the DELAY TIME MULTIPLIER[9] so that the small bright area just 'covers' the part of the waveform it is intended to display in greater detail.

(7) Turn the FUNCTION[15] switch to DELAY (A) - so that the delayed main time base is providing the horizontal deflection - and note the display which comprises the 'wanted' part of the waveform on a much enlarged time scale.

(8) Repeat steps (6) and (7) using different settings of the main time base RANGE[18] switch. Displays involving long delays will probably show a certain amount of time jitter, unless the input waveform is particularly stable. This jitter may be eliminated by using the GATED mode.

2.4.2 GATED function

(9) In step (6) above it will have been observed that variation of the DELAY TIME MULTIPLIER[9] produced a smooth change in the starting point of the main time base sweep. By turning the VELOCITY[11] control in a clockwise direction to show several cycles of the waveform, it can be seen that the start of the main time base sweep can be moved smoothly and progressively from one cycle to the next. If the FUNCTION[15] switch is now turned from DELAY (B)+(A) to GATED (B)+(A) it will be observed that the start of the main time base sweep is at a slightly different part of the waveform.

2.4.2 (continued)

(10) Turn the DELAY TIME MULTIPLIER[9] and note that the main time base is now triggered by certain points on the waveform, and that the triggering point 'jumps' from one point on the waveform to the next. The triggering point may be selected by the TRIGGER LEVEL[23] control in conjunction with the TRIGGER +-[22] switch and the DELAY TIME MULTIPLIER[9] setting.

(11) Select a stable triggering point, just to the left of the part of the waveform it is desired to view in greater detail.

(12) Adjust the main time base RANGE[18] switch so that the desired part of the waveform is embraced by the bright sweep indication.

(13) Turn the FUNCTION[15] switch to GATED (A) and note the display which comprises the 'wanted' part of the waveform on a much enlarged time scale. Since the main time base is triggered from a point on the waveform immediately preceeding the 'wanted' part, any jitter on the waveform is, in all probability, common to both points and a jitter-free display results.

2.4.3 MULTI TRIG function

(14) Set the FUNCTION[15] switch to DELAY (B)+(A) and turn the VELOCITY[11] control so that three or more cycles of the waveform are displayed.

(15) Adjust the main time base RANGE[18] control to about one tenth of the DELAY TIME[10] setting.

(16) With a fairly low BRILLIANCE[8] level, turn the DELAY TIME MULTIPLIER[9] until the main time base sweep is visible as a bright spot near the left hand end of the trace.

2.4.3 (continued)

(17) Now turn the FUNCTION[15] switch to MULTI TRIG (B)+(A) and note that in addition to the bright spot mentioned in (16) above, a series of additional bright spots are occurring on each successive cycle of the display. Movement of the DELAY TIME MULTIPLIER[9] alters the position of the first sweep of the main time base, but later sweeps are triggered in a gated manner by the waveform itself. The triggering point of the multiple sweeps may be selected by varying the TRIGGER LEVEL[23] control in conjunction with the TRIGGER +-[22] switch.

(18) Set the FUNCTION[15] switch to MULTI TRIG (A) and the display will consist of the gated main time base sweeps with a variable delayed sweep of the main time base superimposed.

(19) Alter the setting of the DELAY TIME MULTIPLIER[9] and note how one part of the waveform may be superimposed on a later part of the same waveform.

2.4.4 MULTI TRIG for Sine Squared Pulse and Bar display

The MULTI TRIG position of the FUNCTION[15] switch is of particular value when making measurements using a Sine Squared Pulse & Bar television test waveform. To superimpose the Bar on the top of the Sine Squared Pulse, so that the Bar can be moved relative to the Pulse, proceed as follows :-

(a) With the FUNCTION[15] switch set to MULTI TRIG (B)+(A) set the DELAY TIME[10] and VELOCITY[11] control so as to display at least three complete cycles of the Sine Squares Pulse and Bar waveform.

(b) Using a low BRILLIANCE[8] level, adjust the DELAY TIME MULTIPLIER[9] and the main time base RANGE[18] switch so that the variable delayed sweep of the main time base occurs during the left-hand bar waveform on the display.

2.4.4 (continued)

(c) Adjust the TRIGGER LEVEL[23] and TRIGGER +-[22] controls so that the multiple gated sweeps of the main time base are triggered by the positive-going edges of the sync pulses and embrace all the Sine Squared Pulses (except the extreme left-hand one).

(d) Turn the FUNCTION[15] switch to MULTI TRIG (A) and note the Bar superimposed on the Sine Squared Pulse. Vary the DELAY TIME MULTIPLIER[9] setting and note that the Bar can be moved relative to the Pulse. Since the Pulse and Bar are generated with identical amplitude it is possible to make accurate measurements of the sag at the trailing end of the bar when determining the l.f. response of a video amplifier or transmission system.

Note: If the Sine Squared Pulse and Bar waveform forms part of a composite TV signal, the above instructions apply - but the TRIGGER MODE[21] switch should be set to TV. See also p. 40.

2.4.5 Displaying composite video waveforms

If the main time base is used to view a composite video waveform with the TRIGGER MODE[21] switch set to DC, AC or AUTO, it will trigger on the line sync pulses and indiscriminate lines from both odd and even fields will be superimposed. By switching to the TV position of the TRIGGER MODE[21] switch and with the main time base set to either its 50 or 20 µsec/cm range it will be seen that triggering is now obtained from the field pulses. Both odd and even fields are superimposed so a clear display of the field pulses only is obtained.

Leaving the TRIGGER MODE[21] switch set to TV, turn the FUNCTION[15] switch to DELAY (B)+(A) with the DELAY TIME[10] control set to either the 10 or 100 µsec/cm range. The delaying time base now provides the horizontal deflection and is being triggered from the field sync pulses but only on every alternate field*. A clear display of both field and line periods is now obtained, and may be changed from odd to even fields (and vice versa) by momentarily depressing the BEAM LOCATE[12] button a few times.

* During manufacture, the TF 2200 is adjusted for correct operation in this respect for systems employing 50 fields per second. On other systems RV600 should be re-adjusted, see Section 4.9.9.1.

2.4.5 (continued)

Switch the main time base to its 10 µsec/cm RANGE (18) setting so that it has a duration of approximately one line period; then advance the DELAY TIME MULTIPLIER (9) so that a particular line is selected on the display. (Note that the position of the main time base sweep period may be moved smoothly from one line to the next by the action of the DELAY TIME MULTIPLIER (9) control.)

The waveform obtainable at the B U OUT terminal is a combination of both main and delaying time base bright-up signals. It may be used to indicate the selected line on a picture monitor, if desired. The output voltages are :-

-25 volts during waiting time
+ 5 volts during delaying sweep
+15 volts during main sweep

Having selected the particular line it is desired to examine in greater detail, turn the FUNCTION (15) switch to DELAY (A).

If a considerable delay is necessary between the field trigger pulses and the line under examination the FUNCTION (15) switch should be turned to its GATED (B)+(A) position. Movement of the DELAY TIME MULTIPLIER (9) will now result in the main time base sweep period jumping from one line sync pulse to the next, so that a clear-cut jitter-free display will be obtained when the FUNCTION (15) switch is set to its GATED (A) position. With systems employing positive modulation, the TRIGGER +- (22) switch should be set to + to enable triggering to occur on the positive-going edge of the line sync pulse, and also so that field pulse separation is achieved.

Satisfactory d.c. restoration of the sync pulses will be achieved provided the video is the uppermost part of the displayed waveform on the screen, and provided that the sync pulse amplitude is 3 mm or greater.

2.4.6 Displaying non-composite video waveforms

If it is desired to view a video waveform, such as the output of a camera channel, when sync pulses are only available separately*, proceed as follows :-

* Note : If a mixed sync waveform is available, switch to external trigger, and follow the procedure described in Section 2.4.5 for composite video waveforms.

2.4.6 (continued)

(1) Connect negative-going Field Drive waveform at a level of between 2 and 4 volts p-p to the EXT (B) socket and turn the TRIGGER MODE[21] switch to EXT (B). If the level of the Field Drive waveform is too low, the delaying time base will fail to trigger; alternatively, if the level is too high, trace shortening will result. The triggering amplitude must be varied externally, as no control is provided on the oscilloscope for this purpose.

(2) Apply Line Drive waveform (either positive or negative going) to the TRIG IN socket and turn the ∿-INT-EXT[24] switch to EXT.

(3) With the FUNCTION[15] switch set to its GATED (A) position adjust the TRIGGER LEVEL[23] control and the TRIGGER +-[22] switch to obtain satisfactory triggering of the main time base from the appropriate edge of the Line Drive waveform. Triggering is possible off either the positive of negative going edge of the waveform because the field pulse separator circuit is not in use.

The facility for displaying odd or even fields is retained, and any desired line, or part of a line, may be selected by adjustment of the DELAY TIME MULTIPLIER[9] control in conjunction with the main time base RANGE[18] switch. Operation is very similar to that already described in Section 2.4.5, and the full range of facilities offered by the FUNCTION[15] switch may be employed.

2.5 PHOTOGRAPHIC TECHNIQUES

Waveforms displayed on the oscilloscope screen may be photographed with the aid of a Langham-Thompson Type D5 Hood, or any standard 5 5/8" clamp-on camera mounting. To give immediate access to the tube screen and graticule, even when the camera is attached, the viewing hood is mounted on pintle hinges and fitted with quick-release fasteners.

Alternative camera-mounting arrangements are available if required.

When photographing the trace, reduce GRATICULE[7] illumination to a safe level to avoid fogging the negative.

2.5 (continued)

When making prolonged exposures lasting a number of hours, precautions should be taken to exclude stray light - if necessary, by reducing the level of general illumination in the laboratory.

2.5.1 Graticule and Filter

To remove or change the engraved graticule or green viewing filter, release the two Oddie fasteners securing the viewing hood. The hood may be hinged to the left, or completely removed by lifting it off its pintles. The engraved graticule and viewing filter are held in position by means of a spring clip and a vertical adjustment stop. When replacing the graticule (see OPTIONAL ACCESSORIES for additional types) the engraved lines should be next to the tube faces to minimize parallax error. Symmetrical graticules may be fitted either way up, enabling either red or white illumination to be obtained. The green filter should normally be left in position during photographic procedures.

2.5.2 Single-Shot operation

The ARM-NORMAL-FIRE[20] switch permits single-shot sweeps for photographic purposes when the FUNCTION[15] switch is set to its (A) NORMAL position and when the TRIGGER MODE[21] switch is set to one of its triggered positions, i.e. DC or AC.

ARM position

With the TRIGGER LEVEL[23] control set to a predetermined triggering amplitude and the switch set to ARM, normal triggering will cease.

(a) If the input waveform is not present or its amplitude is too small to provide triggering at the selected TRIGGER LEVEL[23] setting :-

Press the ONE SHOT[19] button and the READY light will glow.

Upon receipt of an input waveform of sufficient amplitude to operate the trigger circuit, one sweep of the main time base will occur and the READY light will be extinguished.

(b) If the input waveform is present and its amplitude is sufficient to provide triggering at the selected TRIGGER LEVEL[23] setting :-

2.5.2 (continued)

Press the ONE SHOT[19] button and a single sweep of the main time base will occur - triggered by the selected triggering point on the waveform.

With very slow sweep speeds it will be observed that the READY light remains on after the button is released, to be extinguished upon completion of the sweep. If the ONE SHOT[19] button is held in during the sweep period, the READY light will stay off for the duration of the sweep and not come on until the sweep is completed. This means that at most time base settings the action of pressing the ONE SHOT[19] button appears to initiate the sweep and light the READY light; in reality, the sweep is triggered by the waveform and is completed by the time the button is fully depressed.

The facility offered under (b) is of questionable utility for the majority of normal applications and it is, of course, the facility described at (a) that is of particular value when photographing 'once only' phenomena.

FIRE position

Single sweeps of the main time base may be initiated by the ONE SHOT[19] button if the ARM-NORMAL-FIRE[20] switch is first set to FIRE and the TRIGGER LEVEL[23] control is set to a non-triggering position. Since the sweep is triggered directly by the action of pressing the ONE SHOT[19] button, the triggering point is in no way related to the input waveform.

2.6 CONTROLS

In the following sections, the uses and functions of the various controls and terminals of the TF 2200 are described in detail. This gives an insight into the capabilities of this versatile oscilloscope.

The index numbers beside the control names refer to the physical layout of the controls on the front panel (see Drawing No. TLB 38728 following p. 42).

2.6.1 C.R.T. Controls

FOCUS[2] — Focuses the electron beam by controlling the voltage on anode A2 of the cathode ray tube.

BRILLIANCE[8] — Controls the brightness of the trace by variation of the c.r.t. grid voltage. This control should invariably be set so that the trace brightness is just adequate. Excessive brilliance should be avoided.

ASTIG[1] — Varies the potential applied to anodes A1 and A3 of the cathode ray tube, thereby controlling the astigmatism of the electron beam. The spot shape and size should be varied by means of the ASTIG[1] and FOCUS[2] controls respectively, to obtain a trace of maximum possible sharpness over the entire display area.

GRATICULE[7] — This control, RV804, varies the illumination provided by the 6.3-volt bulbs at the edge of the c.r.t. graticule. When photographing the display, the illumination should be switched off or kept at a very low level to avoid fogging the negative (see Section 2.5.1). Symmetrical graticules are coloured along one edge, enabling either red or white illumination to be obtained, depending on which way up the graticule has been fitted.

2.6.2 Y Amplifier Controls

The majority of the Y Amplifier controls are situated on the Plug-In Units. Full details of these controls are given in Sections 2.6.3 (Single-Trace Unit), 2.6.4 (Dual-Trace Unit), and 2.6.5 (TV-Differential Unit).

2.6.2 (continued)

The functions of the controls associated with the main Y Amplifier are described below :-

TRANSIENT-WIDE BAND[5] This switch controls the frequency response of the main Y amplifier. In its TRANSIENT position the high frequency response closely follows a Gaussian roll-off curve, so that overshoot on pulses is less than 1%. By setting the switch to WIDE BAND an extended frequency range is obtained, provided pulse overshoot can be tolerated. The WIDE BAND position should, therefore, be used when displaying high-frequency sinewaves, or modulated carrier signals, but the TRANSIENT position should be used when making measurements on pulses with fast rise times.

VOLTAGE SCALE[4] This control is used to measure the amplitude of applied waveforms. Its three coloured scales, engraved 0 to 1, 0 to 2, and 0 to 5, correspond to the coloured range positions of the VOLTS RANGE selectors on the Plug-In Units.

x1 x10 switch[6] If the variable GAIN control on the Plug-In Unit is set to its CALIBRATED position the VOLTAGE SCALE[4] control provides a calibrated shift of either 1 cm or 10 cm depending upon the setting of the x1 x10 switch.[6] The accuracy of VOLTAGE SCALE[4] measurement is not materially affected by the setting of the variable GAIN control, but the relationship between volts and centimetres ceases at settings of the GAIN control other than CALIBRATED.

2.6.2 (continued)

To determine the amplitude of a waveform, the variable GAIN control should be set to maximum and the VOLTS RANGE control on the Plug-In Unit set to obtain a display of convenient height. The VOLTAGE SCALE[4] is then set to 0 and the SHIFT control varied until the datum point of the waveform (e.g. the base of a pulse) is aligned with one of the horizontal hair-lines on the graticule. The VOLTAGE SCALE[4] control is next rotated until the point of the display being measured (e.g. the peak of the pulse) is opposite the same hair-line. The difference in potential between the two points is given directly by reading the VOLTAGE SCALE[4].

Example: With the x1 x10 switch[6] set to x1 and the VOLTS RANGE switch set to 20 volts/cm the VOLTAGE SCALE[4] control provides a total equivalent shift of 20 volts (a 1 cm shift on the screen if the variable GAIN control is set to its CALIBRATED position) and each division of the blue scale corresponds to 0.2 volt. Switching the x1 x10 switch[6] to x10 gives a total equivalent shift of 200 volts (a 10 cm shift on the screen if the variable GAIN control is set to its CALIBRATED position) and each division on the blue scale corresponds to 2 volts.

When the Single Trace Unit is in use, the VOLTAGE SCALE[4] control is permanently in circuit. The Dual Trace Unit is fitted with a MEASURE switch marked A-OFF-B so that the VOLTAGE SCALE[4] may be used with either channel, or disconnected, as desired. The TV-Differential Unit has a switched GAIN control and the VOLTAGE SCALE[4] can only be used when the GAIN switch is set to x1 (DC) because the higher sensitivities are a.c. coupled.

2.6.2 (continued)

A switched x1 x5 GAIN selector is fitted on the Single Trace Unit. This introduces five times the sensitivity so far as measurements using the graticule are concerned, but VOLTAGE SCALE[4] measurements are direct reading, and are thus unaffected.

-+ switch[3]

A + - polarity switch is included for convenience when using the VOLTAGE SCALE[4] control. With this switch set to +, movement of the VOLTAGE SCALE[4] control away from 0 results in an upward shift of the trace; reversal of the switch results in a downward movement.

2.6.6 X Amplifier Controls

X IN

External deflection signals may be applied to this terminal when the internal waveforms generated by the time bases are not required. This facility permits the display of Lissajous figures, or the application of a swept-frequency input.[15] When using the X IN terminal, the FUNCTION selector must be set to its EXT position. The X IN terminal has an impedance of 470 kΩ a.c. coupled with a 0.25 µF capacitor. Input waveforms in the range 2 c/s to 3 Mc/s can be accepted with a mid-band deflection sensitivity of 0.75 to 3.5 volts/cm,[16] depending on the setting of the EXPANSION[16] controls.

No bright-up signal is applied to the cathode ray tube when the horizontal deflection is obtained from an external source. This means that the BRILLIANCE[8] control must be advanced to render the trace visible, and that the flyback is not suppressed in any way. Z modulation may, of course, be applied if required.

EXPANSION[16]

This potentiometer controls the gain of the X amplifier. Expansion is variable from x1 to at least x5 and has little effect on the calibration of the TIME SCALE[14] control. The relationship between time and centimeteres ceases at settings of the EXPANSION[16] control other than CALIBRATED.

X SHIFT[17]

This controls the horizontal position of the display; clockwise rotation causes the display to move to the right. By means of this control it is possible to move the display through at least one screen diameter in either direction.[17] The position of the X SHIFT control has no effect on the accuracy of TIME SCALE[14] or time/cm calibration.

FUNCTION[15]

This eight-position switch selects any one of the following sweep conditions :-

NORMAL: Main Time Base is triggered by the signal and provides horizontal deflection.[20] Additionally, the ARM-NORMAL-FIRE switch permits single-shot operation for photographic purposes (see Sect. 2.5 PHOTOGRAPHIC TECHNIQUES).

2.6.6 (continued)

DELAY: The Delaying Time Base is triggered by the signal and, after an adjustable delay determined by the DELAY TIME controls triggers the Main Time Base.

(B)+(A): Delaying Time Base provides the horizontal deflection. A bright portion of the trace indicates the duration of the Main Time Base.

(A): Horizontal deflection is provided by the Main Time Base.

For detailed instructions on the DELAY function see Section 2.4.1.

GATED: The Main Time Base is triggered by the signal, via a gating circuit. This gating circuit is opened, after an adjustable delay determined by the DELAY TIME controls. The gate closes again after one sweep of the Main Time Base.

(B)+(A): Delaying Time Base provides the horizontal deflection. A bright portion of the trace indicates the duration of the Main Time Base.

(A): Horizontal deflection is provided by the Main Time Base.

For detailed instructions on the GATED function see Section 2.4.2.

MULTI TRIG: The Delaying Time Base is triggered by the signal. After an adjustable delay determined by the DELAY TIME controls a gating circuit is opened and, simultaneously, the Main Time Base is triggered. The gate

..6.6 (continued)

remains open after the first sweep of the Main Time Base, permitting subsequent sweeps to be triggered by external signals, until the Delaying Time Base completes its sweep and closes the gate.

(B)+(A): Delaying Time Base provides the horizontal deflection and bright portions of the trace indicate Main Time Base sweep periods.

(A): Horizontal deflection is provided by the Main Time Base.

The MULTI TRIG position is intended for use with the TRIGGER MODE[21] switch set to: EXT(B), TV, DC, or AC.

The HF and AUTO positions are not recommended for use with the MULTI TRIG facility.

For detailed instructions on the MULTI TRIG function see Sections 2.4.3 and 2.4.4.

EXT: Horizontal deflection is provided by an external signal applied to the X IN terminal. For further details see X IN at the beginning of Section 2.6.6.

TIME SCALE[14] This control is used to measure the duration of applied waveforms, and may be used with either the Main Time Base (A) or the Delaying Time Base (B) - depending on the setting of the FUNCTION[15] switch. Three coloured scales are provided, corresponding to the coloured engraving on the main time base RANGE[18] and DELAY TIME[10] switches.

2.6.6 (continued)

xl x10 Switch[13]

If the EXPANSION[16] control is set to its CALIBRATED position the TIME SCALE[14] control provides a calibrated X shift of either 1 cm or 10 cm depending upon the setting of the xl x10 switch[13]. The accuracy of the TIME SCALE[14] control is not affected by the setting of the EXPANSION[16] control, but the relationship between time and centimetres ceases at EXPANSION[16] settings other than CALIBRATED. When the delaying time base is producing the horizontal deflection - at (B)+(A) settings of the FUNCTION[15] switch - the VELOCITY[11] control must be set to its CALIBRATED position for any type of time measurements. With the FUNCTION[15] switch set to any one of its (A) positions, the TIME SCALE[14] accuracy becomes independent of the VELOCITY[11] setting.

To determine the time interval between two points on a displayed waveform first set the TIME SCALE[14] control to 0 and adjust the X SHIFT[17] control to align the first datum point with one of the vertical hair-lines on the graticule. Then turn the TIME SCALE[14] control and align the second datum point with the same hair-line. The time difference between the two points is given directly by reading the TIME SCALE. If the TIME SCALE[14] control is used to measure the risetime of recurrent waveforms with the time base set to its highest sweep velocity, best accuracy will be achieved if the measurement is made away from the ends of the trace.

Example: With the xl x10 switch[13] set to xl and the main time base RANGE[18] switch set to 20 µsec/cm the TIME SCALE[14] control provides a total equivalent shift of 20 µsec (a 1 cm shift on the screen if the EXPANSION control is set to its CALIBRATED position).

6.6 (continued)

and each division on the blue scale corresponds to 0.2 µsec. Switching the x1 x10 switch[13] to x10 gives a total equivalent shift of 200 µsec (a 10 cm shift on the screen if the EXPANSION[16] control is set to its CALIBRATED position) and each division on the blue scale corresponds to 2 µsec.

6.7 Main Time Base (A) Controls

RANGE or TIME/CM[18]: This twenty-four position switch selects the sweep velocity of the main time base. At minimum EXPANSION[16] setting, the sweep velocity may be varied in 1-2-5 sequence from 2 sec/cm to 50 nsec/cm; maximum EXPANSION[16] increases the fastest sweep to faster than 10 nsec/cm.

TB OUT

A main time base output sawtooth is available from an isolating cathode follower at the TB OUT terminal. The sawtooth is positive-going between the levels +5 to +65 volts and finds application when synchronizing external equipment to the c.r.t. display or for driving a wobbulator, etc.

Caution: Damage to the cathode follower output valve could occur if the TB OUT terminal is short circuited to earth. Safe operating conditions for this valve are assured if the external load has a resistance of 5 kΩ or more.

ONE SHOT[19]
ARM-NORMAL-FIRE[20]

The ONE SHOT[19] button is used in conjunction with the ARM-NORMAL-FIRE[20] switch to initiate single sweeps of the main time base for photographic purposes. For details of operation refer to Section 2.5.2.

2.6.8 Delaying Time Base (B) Controls

DELAY TIME or TIME/cm[10]

This control is a six-position switch providing delaying time base sweep velocities from 100 msec/cm to 1 µsec/cm when the VELOCITY[11] control is set to its maximum CALIBRATED position. Minimum VELOCITY[11] setting decreases the slowest sweep to approximately 0.5 sec/cm.

VELOCITY[11]

Permits slower, but uncalibrated, delaying time base sweeps intermediate between the settings provided by the DELAY TIME[10] control. When making any form of time measurement with the delaying time base producing the horizontal deflection - at (B)+(A) settings of the FUNCTION[15] switch - the VELOCITY[11] control must be set to its CALIBRATED position. With the FUNCTION[15] switch set to any one of its (A) positions, the TIME SCALE[14] accuracy becomes independent of the VELOCITY[11] setting.

DELAY TIME MULTIPLIER[9]

With the VELOCITY[11] control set to its CALIBRATED position, this 10-turn helipot determines the point on the delaying time base run down at which pick-off occurs. (In the DELAY position of the FUNCTION[15] switch the pick-off point corresponds to the start of the main time base sweep.)

The DELAY TIME MULTIPLIER[9] has 100 divisions corresponding to percentages of the total delaying time base sweep period. Since the DELAY TIME[10] control is calibrated in 'time/cm' and not 'time/sweep-period', it is merely necessary to multiply the helipot reading by the DELAY TIME[10] setting.

Example:
DELAY TIME MULTIPLIER[9] setting 4.67
DELAY TIME[10] setting 10 msec/cm

Pick-off point occurs 46.7 msec after the start of the delaying time base run down.

.6.8 (continued)

For further particulars on using the delaying time base, refer to Section 2.4.1.

.6.9 Trigger-Circuit Controls

TRIG IN

The TRIG IN (Type 83) coaxial socket is used for the application of external triggering or synchronizing signals. The ∿-INT-EXT switch[24] must be set to its EXT position when using the TRIG IN socket. A minimum input of between 0.5 and 4 volts peak depending upon the setting of the TRIGGER MODE[21] switch and the triggering frequency, is required for positive locking of the time base. (If 0.5 volt is substituted for 2 mm of trace amplitude, the figures quoted under TRIGGER MODE[21], page 38, apply.)

The input impedance depends upon the setting of the TRIGGER MODE[21] switch :-

TV, DC, AC, & AUTO:	1 MΩ shunted by 25 pF.
EXT (B):	10 kΩ a. c. coupled.
H.F.:	Greater than 1 kΩ, a. c. upled

∿-INT-EXT[24]

This switch determines the source of the triggering (or synchronizing) signal, as follows :-

INT: In this position, which is used for most normal applications, the appropriate time base is either triggered or synchronized by the verical-deflection waveform within the oscilloscope. To ensure positive locking when using the INT position, the signal must be capable of producing a minimum Y deflection of 2 mm (or greater) see TRIGGER MODE[21], page 38.)

2.6.9 (continued)

∿ : If the waveform being displayed is synchronized with the mains supply frequency, and internal sync is not desired, this switch position enables the appropriate time base to be locked to the internal 6.3-volt heater supply, without the need for external connections.

EXT: This switch position enables triggering or synchronization from an external source via the TRIG IN socket. (See TRIG IN on previous page.) See also section 3.4.6 for an example of external triggering.

TRIGGER +- Switch[22]

This switch determines whether the time base triggers on a positive-going or negative-going part of the waveform.

TRIGGER LEVEL[23]

This control determines the point on the waveform at which triggering occurs. Upon moving this control clockwise, the start of the time base sweep will move up the waveform (more positive); similarly the start of the sweep will move downwards (more negative) when the control is turned counter-clockwise. The TRIGGER LEVEL[23] control windows two screen diameters on INT, and nominally 20 V with an external trigger signal. On AUTO this control is inoperative, and on HF it functions as a synchronizing control.

TRIGGER MODE[21]

The six positions of the TRIGGER MODE switch provide the following facilities :-

AUTO:

This provides automatic time base triggering in the following manner :-

An internal pulse-shaping multivibrator free-runs at a repetition frequency of approximately 50 c/s and will lock into synchronization with any signal lying between approximately 20 c/s and 1 Mc/s.

2.6.9 (continued)

If the input signal is disconnected, the multivibrator will free-run at its natural frequency, unsynchronized, the sweep and trigger circuits still operating. This facility is particularly useful when the input signal is being repeatedly changed, as for example, in general fault finding procedures. The visible horizontal trace, which remains even in the absence of a signal, is useful on many occasions as a datum for measurement purposes. The TRIGGER +- switch[22] remains operative on AUTO, but the TRIGGER LEVEL[23] control is inoperative. For this reason the AUTO position is unsuitable for use with complex waveforms and finds its main application when viewing sinewaves.

2 mm p-p sinusoidal trace display will give a triggered time base from 20 c/s to 1 Mc/s (0.5 volt p-p for EXT triggering).

DC:

When the TRIGGER MODE[21] switch is set to DC, the triggering signal is directly coupled; this permits triggering by waveforms having a slow rise time and low repetition frequency, or by a d.c. step function. This position, in conjunction with the TRIGGER LEVEL[23] control may be used to trigger either time base at any desired d.c. potential on an applied waveform.

2 mm p-p sinusoidal trace display will give a triggered time base from d.c. to 1 Mc/s (0.5 volt p-p for EXT triggering).

AC:

In this position, a blocking capacitor is introduced into the trigger input circuit, and the TRIGGER LEVEL[23] settings become independent of the vertical position of the display on the cathode-ray tube. With the TRIGGER +- switch[22] set to '-' triggering will occur on a negative-going part of the trace; when set to '+' it will occur on a positive-going part;

2.6.9 (continued)

in both cases the triggering level is determined by the TRIGGER LEVEL[23] control. Triggering on AC will take place on any signals having a frequency of between approximately 20 c/s to 5 Mc/s, the maximum frequency depending on the amplitude of the waveform. At the higher frequencies, the HF position will probably be found more effective.

2 mm p-p sinusoidal trace display will give a triggered time base from 20 c/s to 1 Mc/s (0.5 volt p-p for EXT triggering).

10 mm p-p sinusoidal trace display extends the triggering upper limit to at least 5 Mc/s (2 volts p-p for EXT triggering).

HF:

In the HF position the internal Schmitt trigger circuit is turned into a Scarrott oscillator which free-runs at approximately 500 kc/s. The TRIGGER LEVEL[23] control becomes a synchronizing control and the TRIGGER +- switch[22] is rendered inoperative. By correct adjustment of the TRIGGER LEVEL[23] control, synchronized time base operation may be obtained from 2 Mc/s upwards.

2 mm p-p display will give a synchronized time base from 2 Mc/s to 25 Mc/s (0.5 volt p-p for EXT triggering).

10 mm p-p display extends the upper limit to 30 Mc/s (2.5volt p-p for EXT synchronization).

TV:

The TV position gives differentiated field lock on any 405-, 525-, 625-line, positive or negative, 50 or 60 c/s television waveform - provided the sync pulse amplitude is 3 mm p-p or more. This position is a.c. coupled and d.c. restored to maintain field lock under adverse conditions. The delaying time base will display either odd or even fields by pressing the BEAM LOCATE[12] button. The TF 2200 is adjusted for correct operation with TV systems employing 50 fields per second; on other

.6.9 (continued)

systems RV600 should be re-adjusted, see Section 4.9.9.1. For practical examples of the use of the TV position refer to Sections 2.4.5 and 2.4.6.

EXT (B): Under most normal circumstances the delaying time base is triggered internally. It may, however, be triggered independently by switching to EXT (B) and applying several volts of fast negative-going triggering waveform to the EXT (B) socket.

EXT (B) Socket: The socket accepts fast negative-going triggering waveforms between 2 and 4 volts p-p, for externally triggering the delaying time base. The input impedance is 10 kΩ, a.c. coupled. For a practical example of the EXT (B) socket in use, refer to Section 2.4.6.

.6.10 Miscellaneous Controls

SUPPLY[25] This double-pole switch controls the application of the a.c. mains supply to the transformer and ventilating fan. A panel lamp, situated[25] beside the switch, lights when the SUPPLY switch is ON.

BEAM LOCATE[12] When the BEAM LOCATE[12] push button is depressed, the gain of both the vertical and horizontal amplifiers is restricted and, at the same time, the time base in use is made to free-run. This push button is used to indicate the direction of the display relative to the centre of the screen when the display has moved off the face of the tube. The X SHIFT[17] and Y SHIFT controls may be thus quickly and correctly adjusted to return the display to the centre of the screen.

2.6.10 (continued)

The BEAM LOCATE[12] button has a second function, resulting from its ability to interrupt the normal triggered operation of the time base. When the TRIGGER MODE[21] selector is set to TV, the delaying time base is triggered by the field sync pulses, but only on every alternate field. Whether odd or even fields are displayed is a matter of chance, and momentary interruption of the time base by means of the BEAM LOCATE[12] button forms a convenient way of changing from odd to even fields.

B U OUT

The trace bright-up waveform is available from an isolating cathode follower at the B U OUT terminal. The output voltages are :-

-25 volts during the waiting time.
+ 5 volts during the delaying sweep.
+15 volts during the main sweep.

A typical use of the bright up waveform is to provide line-strobe markers on a television picture monitor screen.

Caution: Damage to the cathode follower output valve could occur if the B U OUT terminal is short circuited to earth. Safe operating conditions for this valve are assured if the external load has a resistance of 1 kΩ or more.

C F PROBE Socket

This 6-way socket provides power supplies for use with Cathode Follower Probe Type TM 6942 - an optional accessory. For further details of this accessory see Section 2.8.

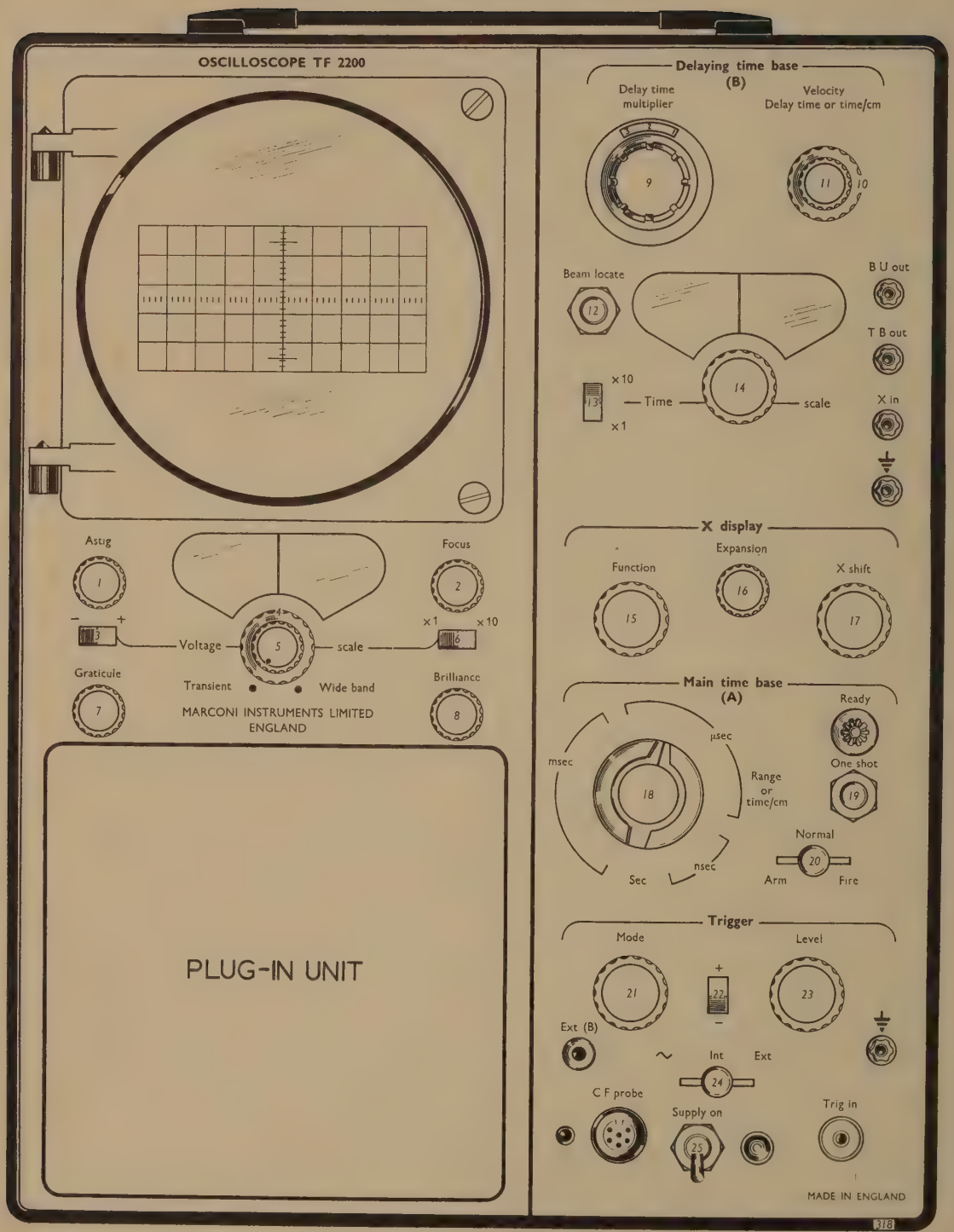
The C F PROBE socket must not be used as a source of power for external equipment.

Z MOD Sockets:

Located at the rear of the oscilloscope, these sockets require up to 3 volts p-p depending on frequency, and will accept 50 c/s to 5 Mc/s. See Circuit Diagram No. XD 37331.

FRONT PANEL CONTROLS

EB 2200
1—6/62
C.P. 5c. 8/63


OSCILLOSCOPE TF 2200
Delaying time base
(B)
Delay time multiplier
Velocity Delay time or time/cm
9
11
10
Beam locate
12
B U out
T B out
X in
×10
13
×1
Time
14
scale
X display
Function
Expansion
X shift
15
16
17
Astig
1
Focus
2
×1
×10
3
Voltage
4
5
scale
6
Graticule
7
Transient
Wide band
Brilliance
8
MARCONI INSTRUMENTS LIMITED
ENGLAND
Main time base
(A)
Ready
µsec
msec
Range or time/cm
18
One shot
19
Normal
20
Sec
nsec
Arm
Fire
PLUG-IN UNIT
Trigger
Mode
Level
21
22
23
Ext (B)
Int
Ext
24
C F probe
Supply on
25
Trig in
MADE IN ENGLAND
318

.7 DIRECT CONNECTION TO Y PLATES

If it is desired to display frequencies considerably higher than the upper limit of the Y amplifier, connection may be made directly to the Y-deflection plates.

The Y plates have a deflection sensitivity of approximately 3.9 volts/cm, see Section 3.10.2.1.

To make direct connection to the plates, the oscilloscope must be switched off and the covers removed as described in Section 4.3. At the output end of the delay line (at the top, on the left-hand side of the oscilloscope when viewed from the front) note the wires soldered to spring connectors which grip the Y-plate pins*. Pull these connectors off the Y-plate pins before unsoldering the wires.

The Y-deflection signal should be balanced with respect to earth, and should be connected to the Y-plate pins via d.c. blocking capacitors of, say, 0.01 µF. Make connection to the c.r.t. by means of the spring clips and on no account solder the capacitors directly to the pins. A resistive network must be included to raise both Y plates to a mean d.c. potential of +320 volts. This is best achieved by connecting each Y-plate pin back to the original delay line wire via a 1-MΩ resistor - this permits Y SHIFT to be applied in the normal way.

* Caution : Movement of the leads between the delay line and the Y-plate pins will affect the performance of the delay line onfast pulses. Before removal of these leads, note their relative positions and, when returning the oscilloscope to its original condition, dress the leads back to their original position. To restore the pulse performance to optimum, display a fast pulse with a risetime of less than 3 nsec and note the reflection on the waveform following the pulse by approximately 0.4 µsec. Adjust the distance between the wires, to obtain minimum reflection.

2.8 USE OF ACCESSORIES

The probes described on this page enable the oscilloscope to suit a variety of conditions, which may be briefly summarized as follows :-

Probe Lead TM 5269 should be used for measurements on low level signals when a loading of 1 MΩ shunted by about 70 pF is acceptable. Use of this lead is, therefore, restricted to relatively low frequencies and slow rise times, when maximum sensitivity and good screening are important.

Probe Unit TM 5793/1 should be used for minimum loading of the circuit under test, and is usable over the entire frequency range of the oscilloscope provided the 20 dB attenuation factor can be tolerated. This precludes its use for accurate low level measurements.

Cathode Follower Probe TM 6942 introduces a loss of only 6 dB and it has an input impedance of 10 MΩ shunted by 8 pF. This probe is intended solely for low level signals of up to 3 V p-p, and is therefore complementary to the Probe Unit TM 5793/1.

Probe Lead, TM 5269 is basically a 30-inch length of low-loss low-capacitance cable terminated at its output end with a Type 83 coaxial plug. Connection can be made to the outer braiding of the cable by means of a screw terminal mounted immediately adjacent to the probe tip; this allows the braiding to be earthed to the chassis of the equipment under test, in close proximity to the actual point of measurement.

If both the equipment under test and the TF 2200 are individually earthed to the supply mains, it is possible that circulating currents will flow round the loop, completed by the braiding of the Probe Lead, and give rise to supply-frequency ripple on the input waveform. In these circumstances ensure that there is only one connection to mains earth when the equipment under test and the TF 2200 are considered together as a single system.

Probe Unit, TM 5793/1 : This probe increases the Y-input impedance to 10 MΩ and introduces an attenuation factor of x10; the shunt input capacitance is approximately 7 pF.

When using the probe, the voltage measurement readings obtained from the VOLTS RANGE switch must be multiplied by x10. The maximum voltage applied to the probe must not exceed 500 volts.

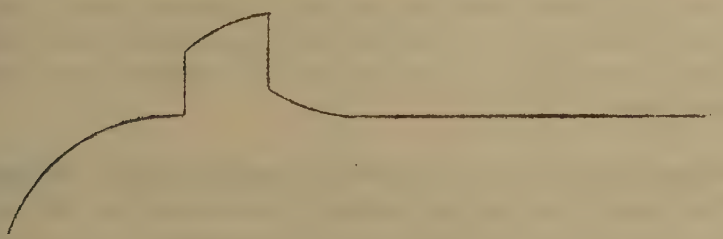
2.8 (continued)

The 30-inch lead attached to the probe is terminated in a Type 83 coaxial plug for direct connection to the Y input of the TF 2200. The probe tip accommodates either a 3-inch test prod or an insulated crocodile clip, both of which are supplied with the probe. An earthing clip is attached to the probe for connection to the 'earth' point of the signal under test.

The probe contains a trimmer capacitor which is accessible through a hole in the side of the probe body, and adjustable by means of a small screw-driver. Correct adjustment may be achieved, without using external test equipment, in the following manner :-

Connect the probe to one of the Y INPUT sockets and set the VOLTS RANGE switch to 0.5 V/cm. Turn the main time base RANGE switch to 10 µsec/cm, and the delaying time base to 100 µsec/cm. Set the FUNCTION switch to DELAY (B) + (A) and the TRIGGER MODE switch to HF. Turn the DELAY TIME MULTIPLIER to an approximate setting of 2 00, then connect the tip of the probe to the B U OUT terminal and adjust the probe so that the displayed bright up waveform assumes rectangular proportions without overshoot or undershoot.

Overshoot



Undershoot

Correct

2.8 (continued)

Cathode Follower Probe TM 6942 increases the Y-input impedance to approximately 10 MΩ with 8 pF in shunt. The probe accepts inputs up to 3 volts p-p at frequencies from 4 c/s to about 30 Mc/s; it attenuates the input signal by approximately 6 dB. Supplied complete with test prod and connecting leads, the probe derives its power supply from the C F PROBE socket on the oscilloscope.

Since the loss introduced by the probe may not be precisely 6 dB, special provision is made to compensate for probe variations. Adjacent to the C F PROBE socket a calibrating contact stud is provided which delivers a 0.5 volt p-p trapezoidal waveform. Contact this stud with the tip of the Cathode Follower Probe, set the VOLTS RANGE switch to 0.05 volts/cm, set the variable GAIN control to its CALIBRATED position, and adjust the CAL 5 cm preset until a 5 cm p-p display is obtained. (See note on following page.)

With the oscilloscope set up in this way, all graticule voltage measurements made while using the Cathode Follower Probe should be multiplied by 2. The VOLTAGE SCALE control is not usable in conjunction with the Cathode Follower Probe.

To render the oscilloscope suitable for voltage measurement without the probe, set the VOLTS RANGE control to CAL and readjust the CAL 5 cm preset to obtain a 5 cm p-p display.

The valve used in this probe is of subminiature type (Mullard Type EC1000) and is wired into circuit. Should it become necessary to open the probe for any reason, proceed as follows :-

(1) Hold both the probe body and the black plastic sleeve at the rear end of the probe, so that they cannot turn relative to each other - then unscrew the knurled end cap and slide it back, away from the probe body.

(2) Remove the fillister head screw from the side of the probe and slide the outer tube off the probe in the direction of the probe tip. To avoid pulling on the lead-out wires, this is best achieved by holding the tube in one hand while pressing the probe tip back into the tube with the other hand.

When re-assembling the probe, align the hole in the side of the tube with the 6BA tapped hole, and be sure that the keyway at the threaded end of the tube engages with the locating lug on the rear moulding; then replace the fillister head screw. The rear end-cap may then be screwed into position - care being taken to prevent the wires twisting relative to the probe during the tightening process.

2.8 (continued)

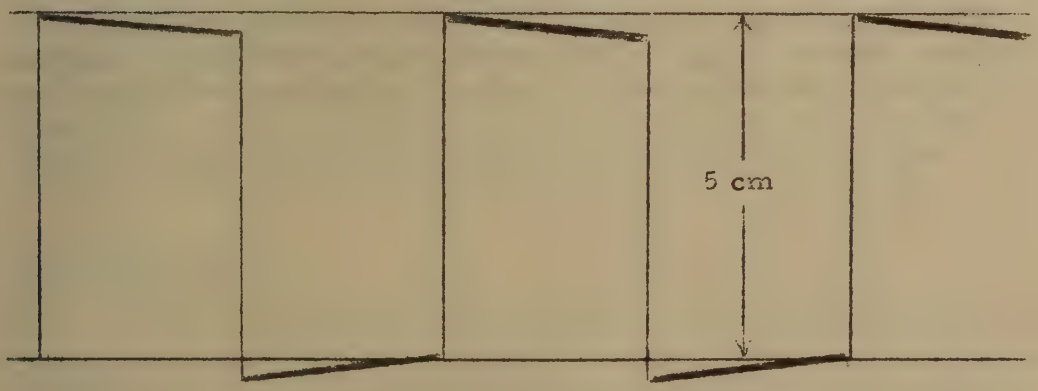
Extension Cable TM 6943 is an optional 24-way cable, 18 inches long; for use when it is desired to operate one of the plug-in units outside the oscilloscope. This is necessary only for certain maintenance operations.

Alternative Graticule : The alternative graticule listed below is fitted in the manner described in Section 2.5.1.

Type TC 37574 for evaluation of k-factors from 0.01 to 0.05.

For further particulars on using this graticule, see B.B.C. Engineering Division, Reprint Article No. A34, 'Sine-Squared Pulse and Bar Testing Methods'. This is a reprint of Technical Instruction V.5, Section 9 (Part 1).

NOTE : When setting up the CAL 5 cm preset, in conjunction with the Cathode Follower Probe, due allowance should be made for the tilt on the waveform due to a.c. coupling.



3

TECHNICAL DESCRIPTION

It is suggested that the following circuit description be read in conjunction with the Block Schematic Diagrams and Circuit Diagrams included in Vol. II of this handbook. Component reference numbers quoted in the text are those shown on these diagrams.

The circuit of the main instrument is covered by eight Circuit Diagrams (XD 37331 to XD 37338) with an additional diagram (XD 37339) to show the interconnections between units. Block Schematic Diagram XD 37330 (Sheet 1) shows the main circuit in a much-simplified form.

Circuit descriptions and diagrams of the Plug-In Units are only included in this handbook when the particular Unit is supplied with the instrument. For this reason there will be discontinuities in the page numbering, unless all the Plug-In Units are obtained. In the event of a Plug-In Unit being ordered separately, the appropriate pages and diagrams are supplied for inclusion in this handbook.

3.4 Y AMPLIFIER (Circuit Diagram XD 37331)

3.4.1 Synopsis

Push-pull signals of plus and minus 300 mV (for 5 cm deflection), centred upon a nominal +150 volts, enter the Y amplifier from the Plug-In Unit via pins 16 and 20 of socket SKA. These signals are fed via cathode followers V101a and V102a to a pair of balanced amplifiers V101b and V102b. Output from these amplifiers is taken, via compensated anode loads, to cathode followers V103a and V103b, which drive the output valves V104 and V105. A balanced delay line is connected to the anodes of V104 and V105.

Internal sync is obtained from a potential divider connected to the first section of the delay line. The signal is connected, via cathode follower V106a, to a d.c. compensated amplifier V106b whose output feeds the trigger amplifier.

D.C. measuring volts are derived by means of an accurate calibrated potentiometer, RV103. This is supplied from 85-volt neon reference sources via switched resistive networks.

Blanking signals from the Dual Trace Unit (appearing in the CHOPPED position only) enter the Y amplifier chassis via pin 6 of socket SKA. They are amplified, without phase reversal, by V107 and are finally applied to the c.r.t. cathode via a 0.01 μF 2 kV capacitor, C711. Z modulation is applied to pin 7 of V107, this arrangement enabling high-sensitivity blanking to be addedat all times.

3.4.2 Circuit Analysis

Input cathode followers V101a and V102a introduce a signal loss of approximately 5%; their output is coupled via series peaking coils L101 and L102 to the balanced amplifier V101b and V102b. RV102 allows the stage gain to be varied from x3.3 to about x1.5 and is normally set for an overall gain of x2. RV101 forms an overall stage balancing control. When correctly set the trace should be central on the c.r.t. screen when the input grids are shorted together.

R118 and R119 form the respective anode loads of V101b and V102b; shunt compensation is provided by L103 and L104 in the TRANSIENT position of switch SW101. In the WIDEBAND position, L105 and L106 are added to overcompensate the stage.

3.4.2 (continued)

R117/C104 and R120/C105 form correction networks to compensate for drift due to screen heating within the entire Y amplifier when displaying very low frequencies or step functions.

Series peaking coils L107 and L108, both damped by 1-kΩ resistors, are fitted in the grid circuits of inter-stage cathode follower V103. A signal loss of approximately 5% is sustained in this stage.

The signal is fed to the control grids of the output valves, V104 and V105, via series peaking coils L109 and L110. Both coils are damped by 1 kΩ resistors. The output valves provide a stage gain of approximately 18 times. R132 and R133 carry 78% of the cathode current unless the BEAM LOCATE button is pressed - which open circuits this route. R131 normally carries 22% of the cathode current unless the BEAM LOCATE button is pressed. R134 and R135 provide d.c. return paths between suppressor grids and cathodes of the output valves without adding capacity to the cathodes; C109 and C110 decouple the suppressors to chassis.

The signal is finally fed to the delay line via series peaking coils L111 and L112.

The balanced delay line has a characteristic impedance of 450 ohms and a total delay of 0.20 μsec. It consists of 30 pairs of balanced, centre-tapped, inductors - each inductor comprising 20 turns of 36 s.w.g. wire, taking up 3/16" length on a 3/16" dia. former. The line has an m value* of 1.4 and gives rise to approximately 2% of pre-shoot when it is correctly adjusted for zero overshoot. Printed board construction is used for the delay line, and the balanced trimmers are supplemented by printed capacitors of the order of 1 pF on the board. To enable all the trimmer capacitors to be adjusted to approximately the same setting, the printed capacitors are of reduced dimensions at the input end of the line.

The sync pick-off valve V106a obtains its input signal from one side of the delay line; the grid circuit of this valve includes R138, C111 and R144 to reduce capacitive loading on the first section the delay line.

* A.C. Hudson, 'Artificial Transmission Lines', Electronic & Radio Engineer, August, 1957.

3.4.2 (continued)

This reduces the pick-off signal from approximately 2 volts/cm on the delay line to some 670 mV/cm (with a +23 volt bias) at the grid of cathode follower V106a. V106a is direct coupled at a d.c. level of +26 volts to the grid of amplifier stage V106b. C171 gives controlled cathode decoupling at high frequencies, and L113 provides series peaking to obtain optimum bandwidth to 30 Mc/s.

The output is coupled, via a voltage dividing network (R149, R147, RV106, C173, and C174), through a low-capacity screened cable to pin 24 of socket SKB. From this socket the output waveform is taken to the trigger input cathode follower, V201b. RV106 enables the INT. trigger signal to be adjusted for zero d.c. bias at the cathode (TP1) of V201b (Drawing No. XD 37332). Throughout the sync amplifier all the time constants are the same value, this enables one trimmer capacitor, C174, to be used for pulse tilt correction. The overall gain from the delay line tapping point to the cable feeding the trigger circuit is unity, so a signal of sufficient amplitude to produce a 1-cm trace provides a 2-volt p-p signal for triggering purposes.

Externally-derived Z modulation, and chopped transient blanking from the Dual-Trace Unit are both applied to V107. A 15-volt p-p waveform at a frequency of 1 Mc/s is fed from the Dual-Trace Unit to the one grid of V107 (pin 2). This half of the valve functions as a cathode follower, and the cathode load is common to the second section of the valve which functions as a 'grounded grid amplifier' of the chopped transient blanking waveform. Externally derived negative-going Z modulation can be applied, via C182 and R167, to the second grid of V107 (pin 7) where it combines with the transient blanking, if present. Due to the difference in bias levels, shaped signals of some 30 volts p-p (d.c. bias approx. +50 volts) appear at the anode (pin 6).

3.5 TRIGGER CIRCUIT (Circuit Diagram XD 37332)

3.5.1 Synopsis

Internal, external, or supply frequency triggering signals are selected by S202 and amplified by V201a and V202a. Triggering polarity is selected by means of S203, and the triggering level is determined by the setting of RV200a. V203 and V204 form a

3.5.1 (continued)

Schmitt trigger circuit whose output is differentiated by C213, C214 and R236. The positive excursion of the differentiated waveform applied to the grid (pin 2) of V205 causes a large anode current which produces a large negative-going pulse across the 180-ohm anode load, R239.

When S201 is switched to TV the rectangular waveform from the Schmitt trigger circuit is differentiated as above but with a much larger time constant (C217, R243), and applied to the grid (pin 7) of V205. The longer time constant, in conjunction with the different bias resulting from R242 and R243, enables anode current pulses to be produced only during the field pulse period of a television waveform.

When S201 is switched to AUTO, R230 and C206 (via R219 and R220) are switched to make the Schmitt trigger circuit function as a multivibrator with a natural frequency of between 25 and 100 c/s.

With S201 switched to HF, the Schmitt circuit is turned into a Scarrott* oscillator by inserting C207 and the network comprising R246, RV200b, R247 and C222, together with R235 and C212, into circuit. The circuit free runs at approximately 500 kc/s enabling synchronism to be achieved from 2 Mc/s upwards by the correct adjustment of RV200b.

When S201 is switched to EXT (B) the main time base functions as though switched to AC, and the delaying time base is connected to the EXT (B) socket to permit triggering from an external source.

3.5.2 Circuit Analysis

Internal trigger signals originating in the Y amplifier are fed, via low-capacity cable, through plug PLB (pin 24) to cathode follower V201b. The cathode of this valve is connected to the INT position of switch S202. When the EXT or ⏚ positions are selected, the input to the cathode follower is short circuited to chassis thus eleminating all possibility of capacitive breakthrough.

* Elements of Pulse Circuits,
F.J.M. Farley, Methuen.

3.5.2 (continued)

Output from the moving contact of S202 is taken through a filter network consisting of R204, C202, R205, L200 and R206, all switched by S201b. The filter elements have been arranged so that S201b is as simple as possible, and in some switch positions superfluous components remain in circuit. The functional components for each switch position are as follows :-

EXT (B):	C202 and R206 provide a.c. coupling.
TV:	C202 provides a.c. coupling, and MR200 positively d.c. restores the sync pulse bottoms to earth potential.
DC:	C202 is virtually short circuited via R205 and L200 to provide d.c. coupling.
AC & AUTO:	C202 and R206 provide a.c. coupling.
HF:	R204 feeds R205 and L200 to make a high-pass filter. This network ensures an adequate sync level at 30 Mc/s and attenuates the signal at 7 Mc/s and below to avoid oscillator paralysis at high signal levels.

The signal is next applied to the grid (pin 2) of V201a which forms part of a long-tailed pair. TRIGGER LEVEL voltage from RV200a is applied to the control grid (pin 2) of V202a, and varies the trigger voltage by an amount equivalent to two screen diameters on INT. The resultant difference signal appears across the anode loads R208 and R212 in opposite sense. Polarity switching is by means of S203, the anode not in use being shunted to chassis via a 47-ohm resistor and C205 to avoid capacitive breakthrough at high frequencies. The 47-ohm resistor prevents parasitic oscillation due to the use of different earth points. The long-tailed pair has a low-frequency gain of approximately 7.5 times and a bandwidth of about 5 Mc/s; theoretically, the gain does not drop to unity until 40 Mc/s has been reached.

When S201b is switched to HF, and AUTO, the junction of R213 and R214 is connected to chassis thereby rendering RV200a inoperative.

Output from the long-tailed pair, V201a and V202a is taken, via one of the moving contacts of S203, through cathode follower V202b, through C206 (or C206 in parallel with R219 and R220, depending upon the position of S201a) to the control grid of one half of the Schmitt circuit, V203, pin 2. The two sections of V203 are connected in parallel.

3.5.2 (continued)

With S201a switched to AUTO the Schmitt input circuit is a.c. coupled via C206, and the circuit free runs at approximately 50 c/s, the time constant being determined by C206 and R230. At all other positions of S201a the Schmitt input circuit is d.c. coupled via R219 and R220; these resistors are included to minimize the capacitive loading introduced by the switch contacts.

V203 and V204b act as a normal Schmitt pair, with V204a functioning as a coupling cathode follower. The principle of operation is as follows :-

When the control grid of V203 passes through +90 volts in a negative-going direction, V203 is biased to cut-off and V204b conducts. When the grid of V203 passes through +91 volts in a positive-going direction, V203 conducts and V204b is biased to cut off; this is the quiescent condition, and gives a threshold of about 1 volt. The signal from the anode of V203 passes through cathode follower V204a and is then attenuated and stabilized by the network R231, R232 and R228. The network drops the d.c. component by about 30% and low-frequency changes are attenuated by a factor of 5. Both the grid of V203 and R228 are returned to the +100 volt line (the former via S201a, V202b, and R208; the latter via R227) so that the circuit is relatively unaffected by variations of h.t. potential.

C210 passes fast edges and high frequencies to provide a x5 increase in the 'h.f. threshold'. This amplitude is greater than the trigger drive signal and, consequently, the circuit will not trigger a second time until the voltage across C210 has discharged to a lower value. This has the effect of blocking the Shmitt circuit to all further trigger signals for about 0.5 µsec after a change-over. The net result is that for signals up to 1 Mc/s the Schmitt behaves normally; at frequencies higher than 1 Mc/s the Schmitt counts down to about 1 Mc/s, the exact value depending on input frequency and input amplitude.

In the HF position of S201, capacitor C207 and the network comprising R246, RV200b, R247 and C222 are connected across the cathodes of V203 and V204b, to make the circuit into a Scarrott-type oscillator. C212, held off by R235, is switched across C210 by contacts 4 and 6 of S201c, to give a very long time constant by comparison with the period of oscillation. The frequency at which the circuit free runs is approx-

3.5.2 (continued)

imately 500 kc/s and is determined by the setting of RV200b. This control permits synchronization with inputs from 2 Mc/s upwards. RV200a is rendered inoperative by contacts 1 and 3 of S201b, which short circuit the junction of R213 and R214 to chassis.

The output from V204a is a rectangular waveform of some 28-volt amplitude which varies in period from infinity to 1 µsec, depending on the input frequency and the setting of the TRIGGER MODE switch. In all positions of this switch, other than TV, the output signal is taken via V205a. The output waveform from the Schmitt circuit is differentiated by C213, C214 and R236 (time constant 30 nsec) and applied to the control grid (pin 2) of V205a. R236 and R237 bias the grid to a point just beyond the nominal cut-off of an ECC88, consequently the positive-going excursions of the waveform drive the valve into approximately 50 mA of anode current, producing a fast sine-squared pulse shape, negative going, across R239. This pulse is approximately 100 nsec h.a.d. with a maximum duty cycle period of 1 µsec; this is equivalent to a mean current not exceeding 5 mA.

With the TRIGGER MODE switch set to TV, the Schmitt output is differentiated by C217 and R243 (time constant 16µsec) and applied to the grid of V205b (pin 7) which is biased to -16 volts by R242 and R243. The circuit operates in the classical field differentiation mode, eight sharp negative-going pulses at twice line frequency appearing at the anode of V205b across R241, coincident with the eight positive-going edges of the field pulse train. The amplitude of these pulses is variable due to RV600 (situated on the X Amplifier board) which alters the mean d.c. potential of the anode of V205b. Due to their low duty cycle and the large charging waveform across C216, these pulses are best viewed by connecting an oscilloscope to the switch side of C218 (contact 23 on the board).

Precautions are taken to minimize break through of trigger voltages into the Y Amplifier via the h.t. supply lines. C211, C208, C209, C220, R229, R227, R233, and ferrite beads on the 100- and 250-volt h.t. lines, are all included for this purpose.

3.6.2.1 (continued)

This problem resulted in the evolution of the circuit shown in Fig. 4, in which the potential across the waiting capacitor is kept constant during the sweep period. The circuit functions as follows :-

Quiescent State : V1 conducting, V2 non conducting.
V1 anode has a potential of -40 volts making the grid potential of V2 -95 volts. The grid potential of V1 would be -75 volts if it were not for the clamping action of D1, which ensures that the potential differs from that of V2 by only 2.5 volts, i.e. -92.5 volts.

Operated State : A 3-volt negative trigger pulse cuts off V1, whose anode potential rises to 0 volts, causing the grid of V2 to rise to -75 volts. V2 is turned on and its anode potential falls to -42 volts, making the grid potential of V1 -96 volts. The diode D1 is thereby cut off by 21 volts and is independent of the waiting capacitor. In the quiescent state the diode would have a forward bias of 20 volts if it were not for its clamping action. Recycling sawtooth raises the grid potential of V1, as before, to return the circuit to its waiting state, the waiting capacitor acting as already described.

Figure 5 incorporates certain refinements over Fig. 4, the chief improvement being the replacement of the battery by a 12 kΩ and a 470 kΩ resistor. The grid potential of V2 can change by about 30 volts for a 1-volt change across the 12 kΩ biasing resistor, showing a 30:1 improvement on the original circuit in this respect. The anode circuit of V2 has been modified to allow a drive waveform to be taken to the Miller clamp diode. The rise time of this drive waveform is improved by shunting the 2.7 kΩ resistor by a 47 pF capacitor; the degraded pulses available for the 1-MΩ circuit are quite adequate for this purpose.

The final circuit is shown in Fig. 6, and this is identical, in essence, to the circuit given on Drawing No. XD 37333. The refinements over the previous circuits are as follows :-

A BEAM LOCATE switch disconnects the '12 kΩ battery' when required, making the circuit free run for trace location purposes.

3.6.2.1 (continued)

When V1 grid is driven in a positive direction by the recycling pulse, this makes the anode of V2 more positive; by connecting the waiting capacitor to this anode a longer waiting time may be obtained for a given value of capacitor, and larger amplitude trigger pulses may be held off. A 33 kΩ resistor (R321) is included in series with the waiting capacitor to minimize the loading on the anode circuit of V2 and maintain the rise time of the signal applied to the Miller clamp diode. By means of switching, not shown in Fig. 6, the waiting capacitor is still taken to earth on the faster ranges when small-value capacitors can be used. A 47 kΩ resistor (R316) is permanently included in the discharge path of the waiting capacitor to increase the waiting time on the slowest ranges; this is left in circuit on the faster ranges, where it serves no useful purpose but has no detrimental effect.

To maintain a relatively constant grid base for V3; a diode D2 (MR301) and a 15 kΩ resistor (R324) are included. This stabilizes the recycling point and ensures greater constancy of trace length, despite the widely differing values of waiting capacitor used.

Certain components are not included in Fig. 6 for the sake of simplicity, and reference should be made to the main Circuit Diagram, Drawing No. XD 37333.

R300 is added to make the circuit consistent with the Main Time Base - but it plays no part in the operation of the Delaying Time Base. R310 and R313, compensated by C304, are included to enable the time base to be stopped when not in use by means of S401a which connects one end of R313 to the -150 volt line.

R309 and R319 drop the screen volts of V301a and V302a to +30 volts.

R320 is a fixed bleed resistor to stabilize the Miller equilibrium level, and R322 is switched to compensate for the varying load currents imposed by R333 and R334.

R302, R305, R306, R323, C302 and C310 are stoppers, decoupling components etc.

3.6.2.1 (continued)

The waiting capacitors, C306 to C309, are connected via S210f on the TRIGGER MODE switch in such a manner that, in the TV position, a fixed waiting time of approximately 30 msec is added, independent of time base range.

3.6.2.2 Miller Circuit In the quiescent state, the Miller anode (V304 pin 6) is d.c. coupled to its grid via cathode follower V304b, R336, cathode follower V306b, and diode V303. This high degree of feedback ensures that the output potential at pin 8 of V304 is determined, during the waiting time, almost entirely by the ratio of R336 to R337 and that when V303 is cut off by the drive waveform from the multivibrator, the Miller valve will start its 'run up' immediately, without a negative-going step being generated at the start of the 'run up'.

The linearity of the sweep increases with the gain of the valve and it may be assessed by comparing the peak-to-peak grid potential with the aiming potential. With the VELOCITY control in its maximum (short circuit) position, the nominal aiming potential is -135 volts and the peak-to-peak grid waveform is less than 0.5 volt. The charging current through C312 to C317 therefore varies by less than 135.5/135 or 0.37%. This means that the incremental linearity differs between start and finish by less than 0.37%. The amplitude of the grid waveform therefore affords a quick check on the linearity of the time base.

The VELOCITY control, RV301, alters the aiming potential by about 5 times, thus reducing the velocity by about 5 times. At reduced aiming potentials an increased amount of non-linearity is introduced but, since time measurements can only be made at the maximum setting of the VELOCITY control this in no way impairs the accuracy of the oscilloscope.

The Miller clamp diode, V303, has a d.c. heater supply to ensure freedom from jitter due to possible heater-cathode emission or leakage.

3.6.2.3 Delay Pick Off The output sawtooth from the cathode (pin 8) of V304b has an amplitude of approximately 105 volts. This is combined with the bright-up signal from the cathode (pin 8) of V301b, which has

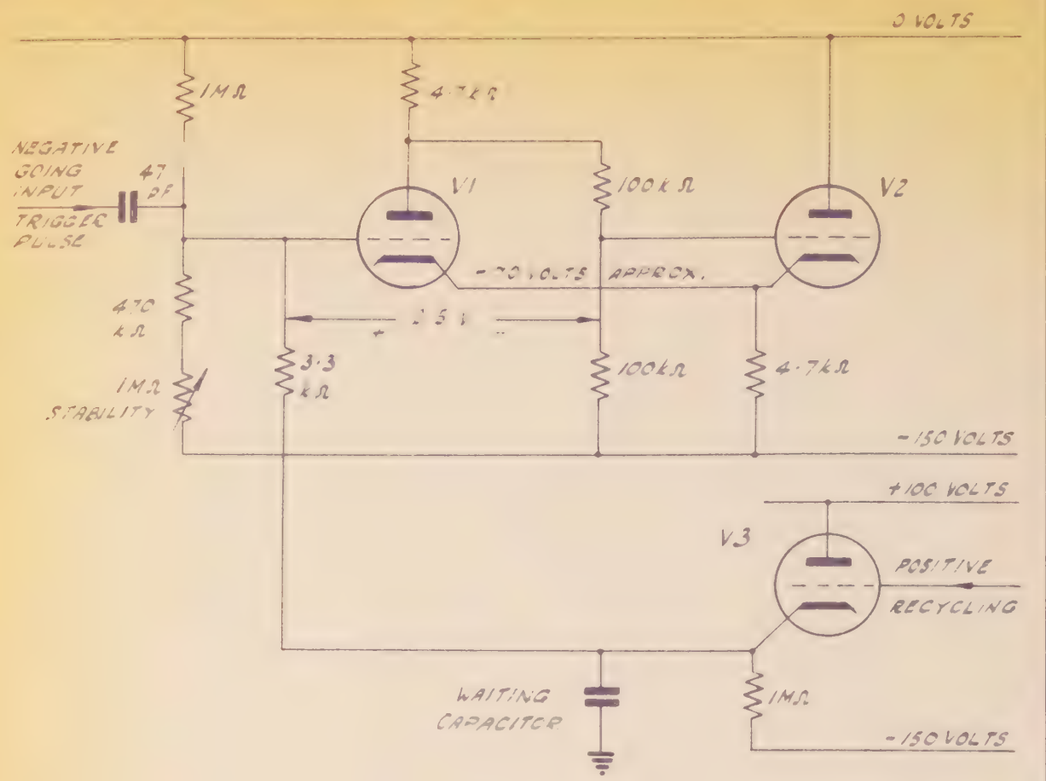


FIG. 1

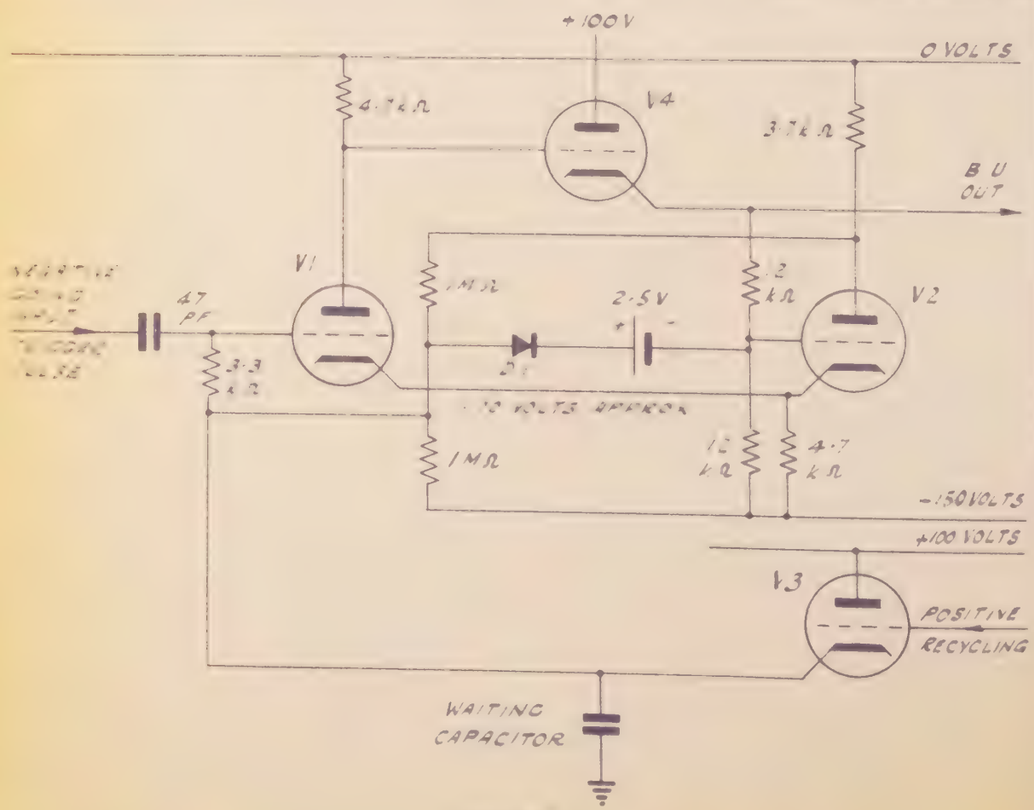


FIG. 4

TITLE

TF 2200 INPUT SCHMITT CIRCUIT ANALYSIS

DRAWN	DATE	CHKD.	APPD.	TRC'D.	ASSEMBLY	STOCK LIST	DRAWING NUMBER
J. K. M.	4.3.62			H.F.		TF 2200	XD38275

MARCONI INSTRUMENTS LTD.

SHEET / OF / SHEETS

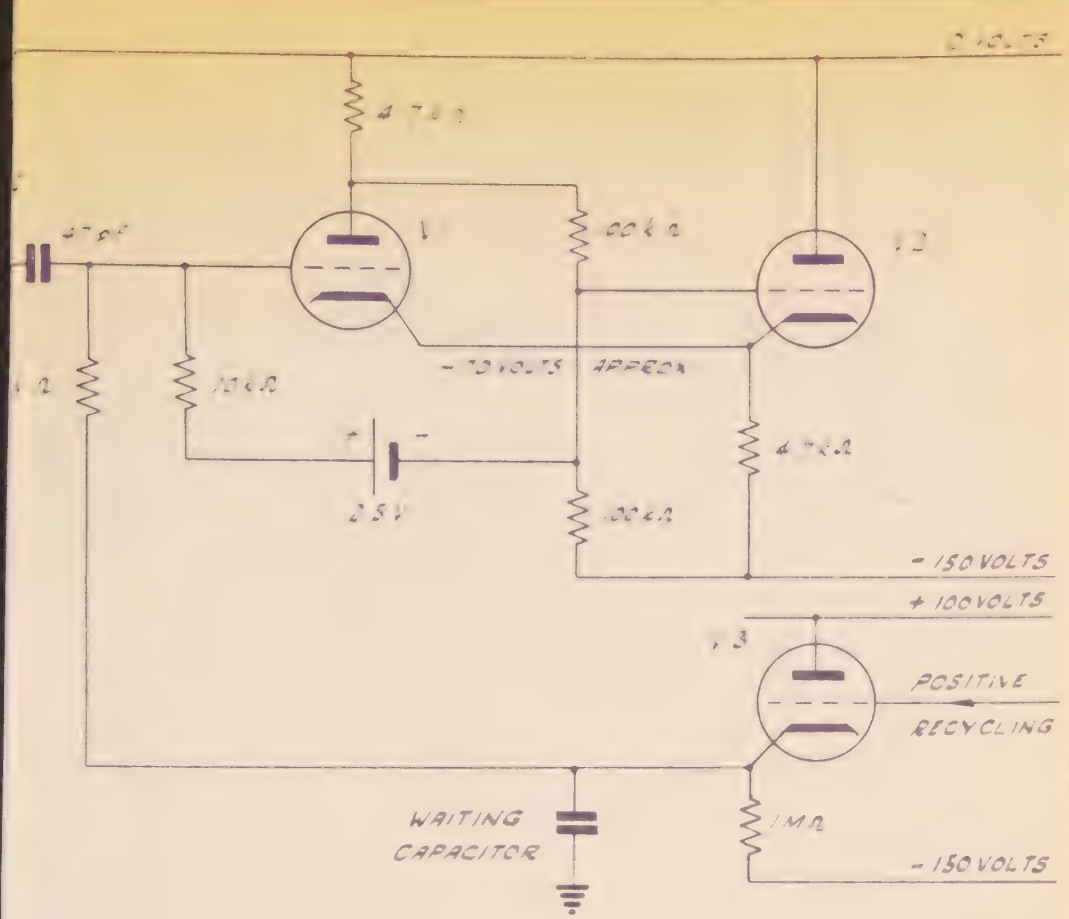


FIG. 2

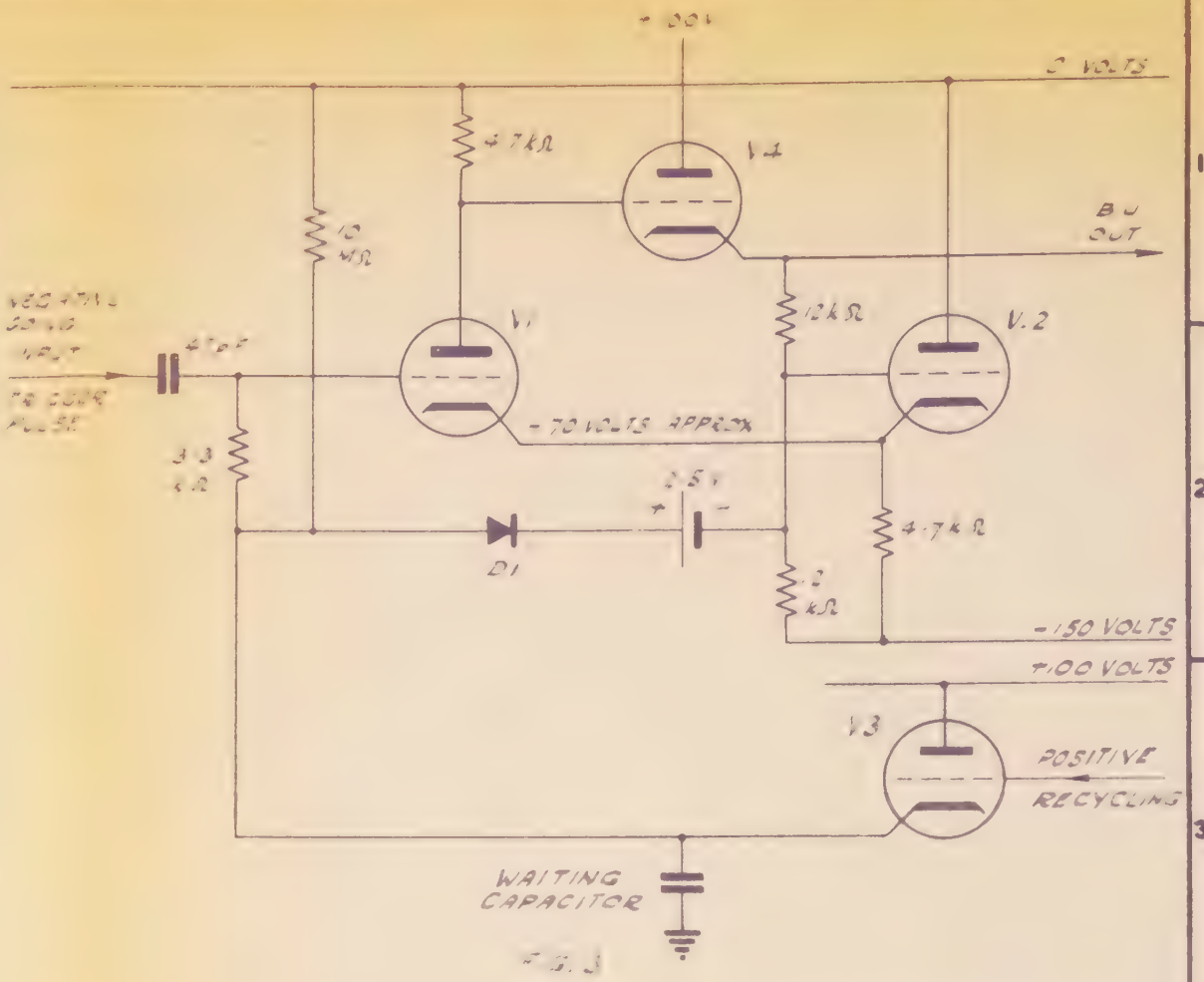


FIG. 3

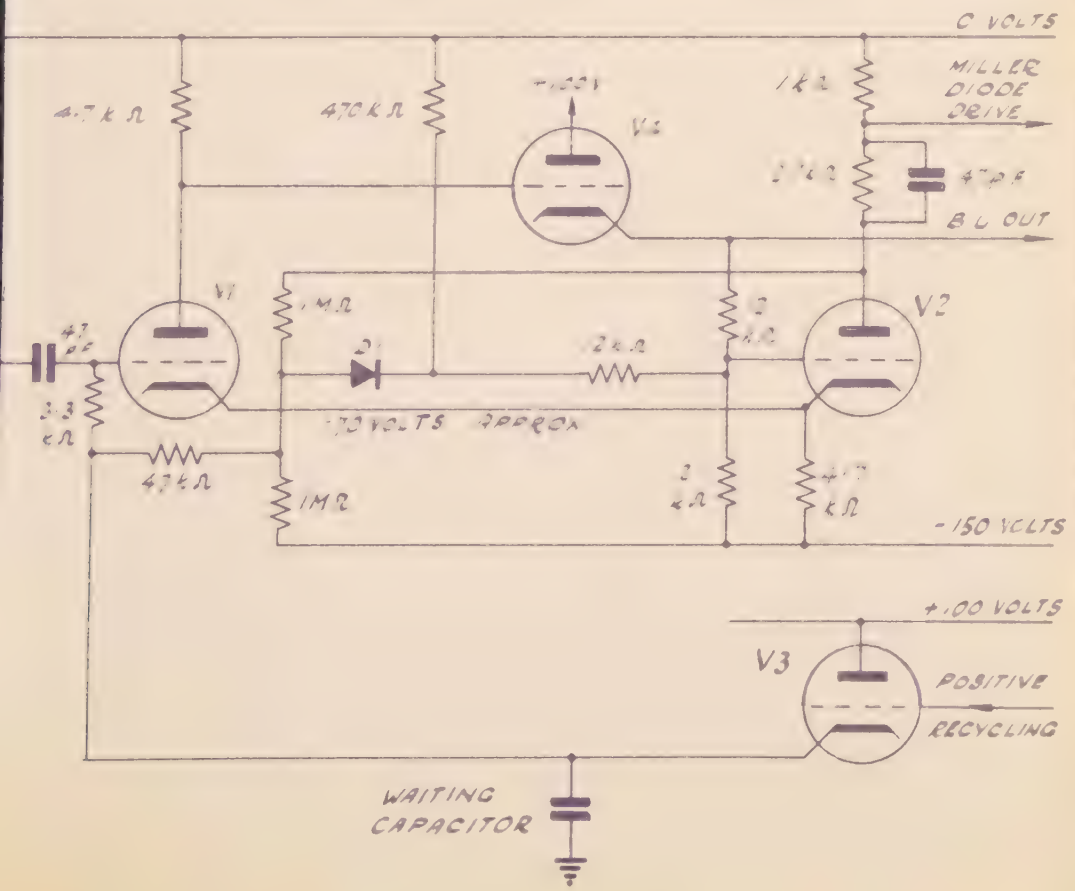
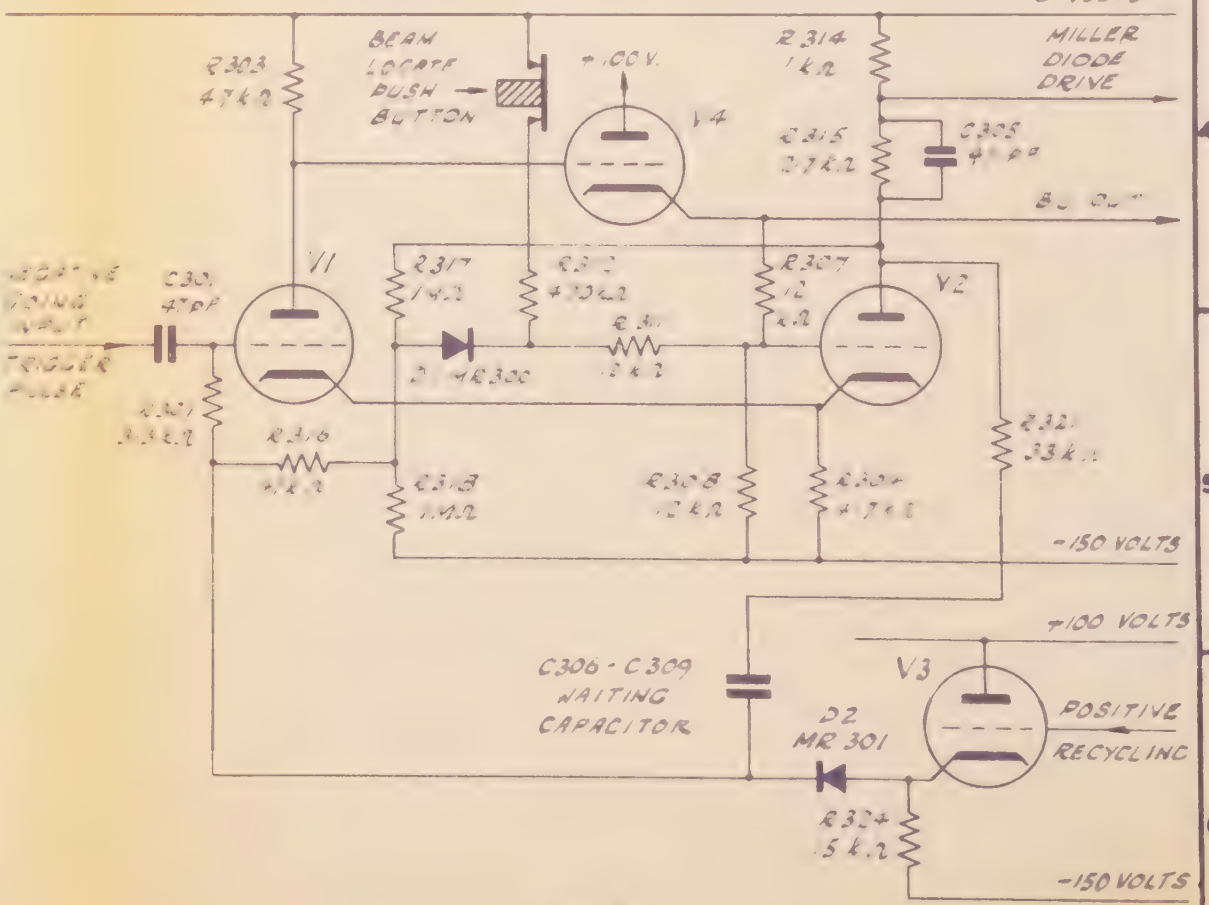


FIG 5



F.G 6

XD 38275

3.6.2.3 (continued)

an amplitude of approximately 40 volts, by means of R338 and R341. The resultant waveform appearing at pin 2 of V305 comprises a 93-volt sawtooth on a 5-volt pedestal. V305 operates as a normal Schmitt trigger circuit with V306a maintaining a constant current in the cathode circuit; this ensures constant output pulses across the anode load R344, R345. The voltage drop across R344 and R345 would produce a Schmitt threshold of unnecessarily large magnitude if the junction of R347 and C321 was connected directly across the anode load. Instead, these components are connected to the junction of R344 and R345, and this amount of feedback provides an adequate margin of stability.

RV308 sets V305 grid (pin 9) to 52.8 volts when the DELAY TIME MULTIPLIER control, RV310, has a dial setting of 1 00 : RV309 sets the grid to 123.2 volts when RV310 has a dial setting of 9 00. In conjunction with R351, which gives a three-point tracking law, this gives greater accuracy than setting up RV310 at the extreme limits of its range.

3.7 FUNCTION CIRCUIT (Circuit Diagram XD 37334)

The Function Circuit routes the synchronizing signals depending upon the position of the FUNCTION switch, S401, as follows :-

3.7.1 NORMAL(A)

S401h earths the junction of R406 and R407, making the grid potential of V401b -5.5 volts. R401 is joined to R402, via S402 and S401g, making the grid of V401a -19 volts. V401b is thus acting as a cathode follower, and V401a is biased to cut off. The Delaying Time Base is inoperative in the NORMAL position of the FUNCTION switch, so no signals are applied to the grid of V401b via C402. The cathodes of V401 will be residing at about -3.5 volts, and this potential will be passed on through R413 to gate diodes MR404 and MR405; MR404 will be conducting and MR405 non-conducting.

Negative-going triggering signals entering the circuit at 'X' will be passed via S401c, and pass through the gate diodes to the main time base input valves.

3.7.2 NORMAL (A) but with S402 in the ARM position

When S402 is switched to ARM, R402 is disconnected from R401, and MR401 is no longer short circuited. V401 now functions as a bistable stage. Normally, V401a will be cut off and V401b conducting. MR402 clamps the junction of R408 and R409 at zero volts; this ensures that V401b has a grid potential of +10 volts and makes the cathodes reside at +12 volts. Gate diodes, MR404 and MR405, are biased so that MR404 is non-conducting and MR405 conducting; trigger pulses entering via S401c are therefore prevented from reaching the main time base.

When the ONE SHOT push button is depressed, a negative-going edge is passed via S402 and C401 to the grid of V401b; this makes the bistable circuit change over so that V401a starts to conduct and V401b is cut-off. A 50-volt drop results across R405, lighting the neon lamp ILP400, and making MR401 clamp the junction of R406 and R407 at zero volts; this holds the grid potential of V401b at -5.5 volts. Due to the current through V401a, the common cathode potential is approximately +0.2 volts and this opens the gate diodes. MR404 is, therefore, conducting and MR405 non-conducting, so that any sync pulses appearing at S401c are passed to the main time base. The first pulse to do so will fire the main time base and display a scan. At flyback, the negative edge of the bright-up pulse, differentiated by C400 and R402, restores the bistable circuit to its normal state - thus stopping any further triggering of the main time base after the first single shot. The READY light, ILP400, is extinguished to show that the single shot has been made.

To ensure satisfactory operation on the 50 nsec/cm range MR400 is included to suppress the positive-going differentiated edge of the bright-up pulse; R400 reduces the capacitive loading on the bright-up cathode followers. R415 is included to discharge C403 in a controlled fashion, producing the best shaped pulse for reliable ONE SHOT triggering.

3.7.3 NORMAL (A) but with S402 in the FIRE position

In this position the circuit reverts to the first state, as with S402 in the NORMAL position (see Section 3.7.1) but the ONE SHOT push button is still in circuit.

3.7.3 (continued)

Every time the ONE SHOT button is pressed, the negative-going pulse is passed via V401b (acting as a cathode follower) through the gate diodes to the main time base. It should be noted that internal sync will still be present on S401c and will trigger the main time base in addition to the push button. If ONE SHOT operation is required alone, the trigger selector switch, S202, should be set to EXT or the TRIGGER LEVEL control rotated to one of its end stops.

3.7.4 DELAY (B) + (A) and DELAY (A)

In both these positions V401b acts as a cathode follower and V401a is cut off. The delaying time base is allowed to trigger because wafer S401a (Drawing No. XD 37333) is no longer connecting R313 to the -150 volt line. After a delay period, set by the front panel controls, the delay sync pick off circuit sends a negative pulse via C402 to the grid of V401b. This is then passed to the main time base to trigger it in the normal way. Sync signals entering at S401c are not passed by this switch in the DELAY positions, so a single delayed pulse is made available. The only difference between the (B) + (A) and the (A) positions is that in the (B) + (A) position the delaying time base produces the scan, while the duration of the main time base is indicated by a bright portion of the trace; in the (A) position, the main time base produces the scan. This is true for all the other (B) + (A) and (A) positions of the FUNCTION switch.

3.7.5 GATED (B) + (A) and GATED (A)

This position is very similar to the second mode of operation (see Section 3.7.2). V401 is switched as a bistable circuit and the cathodes normally reside at +12 volts shutting off the gate diodes, MR404 and MR405, to prevent sync signals from S401c from reaching the main time base. After the appropriate delay a negative pulse from the delay pick-off circuit, entering via C402, changes the state of V401 and lowers the cathode potential to +0.2 volt. This will open the gate diodes and allow the next trigger pulse entering via S401c to trigger the main time base. As in the single shot mode, after one scan of the main time base the negative edge of the bright up pulse is fed via R400 and C400 to the grid of V401a. This returns the bistable circuit to its normal state and stops any further triggering until the delaying time base produces another pulse.

3.7.5 (continued)

At S401c trigger signals are taken from the y lead instead of x. Line sync is available from the y lead at all settings of the TRIGGER MODE switch, while in the TV position, field sync is applied to the x lead. (See S201d, Drawing No. XD 37332). This enables the delaying time base to lock on field sync, while the main time base gates on line pulses.

3.7.6 MULTI-TRIG (B) + (A) and MULTI-TRIG (A)

This position enables a waveform to be displaced in time and superimposed on the original, thus facilitating measurement of tilt on squarewaves, etc. Its most important use is for the display of television Sine-Squared Pulse and Bar test waveforms.

V401 is switched as a bistable circuit which differs from the GATED arrangements by the inclusion of a by-pass loop comprising C404 and MR403. This loop passes the negative edge of the gate opening waveform, present at the cathodes of V401, direct to the main time base - thus causing a single shot. Subsequent pulses from cable y pass through S401c and the gating diodes to trigger the main time base for the duration of the delaying sweep. The by-pass loop imposes no load upon these subsequent pulses due to MR403 cutting off. The gate remains open for the duration of the delaying sweep, until flyback occurs; the trailing edge of the delay bright-up waveform then enters via C400 and switches V401 back to its normal state, thus closing the gate.

The following paragraphs describe the above sequence of operation in greater detail :-

After a delay, determined by the setting of the DELAY TIME controls, a negative pulse enters via C402 and makes V401 change from the waiting to the operated state; this alters the cathode potential from +12 to +0.2 volts. This step waveform is passed via C404, through S401h and MR403, direct to the main time base where it initiates the first sweep. The same step waveform passes through R413 and opens the gate. This enables pulses, entering via cable y, to pass through S401c and the gate in order to trigger the main time base for the remainder of the delaying sweep period.

3.7.6 (continued)

These pulses are adjusted in amplitude by C213 (see Drawing No. XD 37332) to obtain 11 volts at Test Point 4. The shunt capacitance of cable y reduces this to 5 volts at Test Point 2. No loading is imposed by the by-pass circuit due to MR403 being cut off. After differentiation by the main time base input network, the pulses have an amplitude of 3.5 volts when measured at Test Point 1 (see Drawing No. XD 37335).

During flyback of the delaying time base, the trailing edge of the bright up pulse turns V401 (via R400 and C400) back to its normal state. This stops further triggering of the main time base until the delay pick off provides a further negative pulse, via C402, to start the sequence all over again.

The net result is that the main time base makes one delayed sweep follwed by several (depending on the control settings) gated sweeps. This enables part of the input waveform to be delayed by a variable amount and displayed superimposed on the remainder of the waveform.

3.7.7 EXT

Both time bases are stopped by S401a so the position of the gates is of no consequence.

3.7.8 General

A few components have not received mention, and the functions they perform are explained as follows : R419 and R418 provide bias for MR403 and MR405. R416 and R417 produce a suitable voltage to light ILP400, as required, and also to charge C403 so that it may be discharged, as required, by S403. R410 is included so that in the NORMAL position of S402 the READY light does not flicker under any conditions.

3.8 MAIN TIME BASE (Circuit Diagram XD 37335)

The main time base is so similar to the delaying time base that only the differences will be discussed. For an explanation of the bistable input circuit refer to Section 3.6.2.1, and for the Miller circuit see Section 3.6.2.2.

3.8.1 Comparison with Delaying Time Base

In the input bistable circuit of the main time base, R515 and L501 are additional components. R515 raises the mean potential of the bright up pulse by about 10 volts, making the displayed trace brighter than that of the delaying time base by this amount. L501 is added to improve the bright up rise time - particularly necessary on the fastest range, 50 nsec/cm.

R531 and R532 are switched bleeds for the clamp diode V505, and they function in much the same way as R322 in Drawing No. XD 37333.

Cathode follower, V508b, maintains the sweep linearity despite variations of X amplifier input capacity on the top few ranges. This extra valve eliminates loading of the compensated potentiometer formed by C532, R572 and R573.

Unlike the delaying time base, where there is a separate preset potentiometer for each range, the main time base uses one set-up potentiometer for a group of three ranges. It is important that the three range resistors should not load their associated preset potentiometer, and for this reason an additional valve, V501b, is fitted.

V506a receives a differentiated positive edge at main time base flyback (via C512 and R535) and passes this to the Dual Trace Unit to change from A to B channel in the ALT mode. This cathode follower not only presents a low-impedance output to the Dual Trace Unit, but it completely suppresses the negative-going pulse which occurs at the start of each scan. The removal of this negative-going pulse is necessary to avoid the possibility of X to Y breakthrough at the start of each scan. C515 has a maximum value consistent with not reducing the output pulse on the top time base range; in this way maximum suppression of the negative going edge is achieved.

3.8.1 (continued)

Bright-up mixing is obtained by feeding the delaying time base bright-up into cathode follower V501a, and the main time base bright-up into cathode follower V502b. When the two cathodes are connected via S401f, the output is due to whichever input signal is the more positive. The output voltages are : -25 volts during the waiting time, +5 volts during the delaying sweep, and +15 volts during the main sweep - available from an isolating cathode follower, V502a, at the B U OUT terminal.

V506b is the isolating cathode follower for the main time base whose output is available at the TB OUT terminal. Cathode followers V502a and V506b are both d.c. coupled, so that external short circuits can alter the operating conditions. Prolonged shorting to earth of either B U OUT or TB OUT will eventually damage the valve concerned; the rest of the circuit will be undamaged.

R562, R563, and R565 are parasitic stoppers. R572 and R573 form a compensated potentiometer whose ratio is slightly smaller than the network in the delaying time base; this allows for the shunting effect of R574, and the loss introduced by cathode follower V508b. R574 is included to back-off the grid/cathode standing voltage of V508b so that both main and delaying time base voltages are nominally the same.

On the main time base MR501 is connected to the top of R510 instead of the bottom of R301 as in the delaying time base. The fixed waiting time required for the TV position of the TRIGGER MODE switch precludes this method of connection in the delaying time base. On the top delaying time base range it would be necessary to charge 0.47 µF through 3.3 kΩ by about 7 volts in 3 µsec. This is, of course, impracticable as approximately 1 ampere at 3 kV would be necessary. Recycling would, therefore, occur long before the 0.47 µF capacitor had charged and every field pulse would trigger off a large number of fast shots, causing a confused display. If, however, the diode is connected directly to the waiting capacitor (as in the delaying time base), the waiting capacitor must charge beforerecycling can occur, giving rise to a single shot for every field trigger pulse. As the recycling cathode follower cannot charge the waiting capacitor at one ampere, the fast delaying time base ranges get considerably larger on the TV position; this is only a length change and in no way affects the calibration.

3.8.1 (continued)

In the main time base the waiting capacitor is switched on a range-to-range basis and the waiting time is not a fixed value in the TV position. This permits an alternate form of connection. The advantage of connecting MR501 to the top of R510 is that, just before recycling, the test point TP1 is clamped by a source impedance of 100 to 200 ohms, thus reducing the sync pulse amplitude at that point by some two or three times due to R509. This means that the recycling point will be less affected by trigger pulses, and trace length variations will be minimized. Typical values for trace shortening are about 2 mm on delaying time base, and 1 mm on main time base, when displaying a 300 kc/s sine wave with a horizontal sweep of one screen diameter.

RV500 (RV300 in the delaying time base) adjusts the trace length by changing the working potentials in the recycling loop. In this way the output has to change with potentiometer setting to maintain the same recycling voltage. The range of this control is adequate to take up all circuit tolerances and enables the trace to be set to 10.5 cm (105 volts of sawtooth from the Miller).

V505 is fed from a d.c. heater supply to ensure freedom from supply-frequency jitter due to possible heater-cathode emission or leakage.

Referring to Sheet 2 of Drawing No. XD 37335, it will be seen that most of the ranges are switched in groups of three, with a single setting-up potentiometer for each group. This is not practicable on the top three ranges due to stray capacitance being a significant circuit component. On the next three lower ranges, the group switching method is just possible by adjusting the capacitance rather than the range resistors; the latter are taken directly to the -150 volt line to obtain the maximum aiming potential.

All ranges have a single range resistor except for the slowest three, where a series circuit is used to eliminate the necessity for unduly high component values with possible switch leakage troubles.

3.8.1 (continued)

Most of the waiting capacitors are connected to the bistable circuit via a 33 kΩ resistor, R530. Connecting the waiting capacitors to the anode in this way enables a longer waiting time to be obtained for a given value of capacitor. Due to the waveshape at the anode, this method becomes impracticable on the faster ranges and, for this reason, C510 and C511 are connected to earth.

3.9 X AMPLIFIER (Circuit Diagram XD 37336)

3.9.1 Synopsis

Sawtooth signals from the delaying time base, main time base, or X IN terminal, are selected by the FUNCTION switch wafer S401j and applied to the grid, pin 2, of V601. X SHIFT and TIME SCALE voltages are applied to the corresponding grid of V602. These valves amplify the signal and are directly coupled to the X plates of the cathode-ray tube. The overall gain of the X amplifier is controlled by a front-panel EXPANSION control, RV602, connected across the cathodes of the two valves. Shunted across this control, a preset resistor, RV601, enables the minimum gain to be pre-adjusted. Contacts on the BEAM LOCATE push button normally short circuit resistor R605. When the button is depressed, the additional 3.3 kΩ resistance in the cathode circuit reduces the gain and restricts the deflection to facilitate trace location.

The shift produced by the TIME SCALE control originates from an 85-volt stabilized supply. This voltage forms a reference against which the time base ranges are adjusted, and no preset adjustments are required for setting up the TIME SCALE control.

3.9.2 Circuit Analysis

A 36-volt sawtooth, selected from either time base and centred around + 100 volts, is fed to pin 2 of V601. Some ±40 volts of shift and ±18 volts (or ±1.8 volts, depending on the setting of S600) of measuring voltage is applied to pin 2 of V602. With the EXPANSION control at minimum (maximum resistance condition) and RV601 set to the centre of its range, typical EL822 valves should give an output of 96 volts at each anode. This will produce 10.5 cm of trace with a nominal tube deflection sensitivity of 18.3 V/cm.

3.9.2 (continued)

The shift and measuring voltages are normally equally mixed across R611 and R612, before application to the grid, pin 2, of V602. With S600 in the x1 position, the TIME SCALE voltage is subjected to a 20:1 reduction instead of 2:1 due to the inclusion of R613 and R614.

L601 and L602 are set to give optimum pulse response without excessive overshoot. Under these conditions the bandwidth should be 3 dB ±1.5 dB at 3 Mc/s.

R602 and R610 are grid stopper resistors, their rather high value of 220 ohms being dictated due to the necessity for long grid and anode leads.

3.10 E.H.T. UNIT (Circuit Drawing XD 37337)

3.10.1 Synopsis

V701 with T701 forms a tuned oscillator with a frequency of about 20 kc/s. The rectified output from one of the secondary windings produces the cathode voltage for the cathode-ray tube and this is fed back via R715, RV701, R711, R709 and R710 to cathode follower V702a. This valve is connected via an isolated feedback winding (pins 13 and 14 of T701) to control the bias on V701. In this way a regulated output, referenced to the +350 V line, is obtained which is relatively independent of load.

Pins 3 and 6 of T701 produce a 'floating' voltage of -1100 volts so that d.c. coupled bright-up can be connected to the c.r.t. grid, together with a suitable bias potential of -1050 volts. The voltage between pins 5 and 8 added to that between pins 5 and 2 produce 4.5 kVp which, when voltage doubled by V703 and V704, produce +9 kV for the final anode of the c.r.t.

Should the oscillator stop working for any reason, clamp diode V702b holds the grid potential of V701 at about -5 volts, thereby preventing excessive anode current. In order to find out why the oscillator is not working it is merely necessary to connect an oscillator, through a 0.1 µF capacitor, to TP1. Tune the oscillator, at about 20 kc/s, for maximum output on any winding using a signal

3.10.1 (continued)

level of between 3 and 15 volts r.m.s. Full output volts on maximum load should be generated with an input of about 5 volts r.m.s. It should be noted that the e.h.t. circuit will stop oscillating when the external oscillator is connected into a perfectly normal circuit - R703 has been included for this purpose. When the fault has been located and cleared, the external oscillator must be disconnected before the circuit can operate on its own.

3.10.2 Circuit Analysis

With the circuit in its quiescent state V702b clamps the grid of cathode follower V702a at -8 volts; its cathode voltage will be approximately -5 volts and this appears as bias on the grid of V701. With V701 anode at +300 volts, and the screen at +250 volts, this valve is ideally biased in class A. Positive feedback via the floating grid winding will cause oscillations at the resonant frequency of the anode circuit. The d.c. outputs will increase with time until C709 has 1 kV across it. At this moment the junction of R711 and R710 will have reached -9 volts, and any further increase in the voltage across C709 will result in V702a passing this change on to the grid of V701. The grid will go more negative and tend to reduce the output. Typical equilibrium state is reached when the grid potential of V701 reaches -20 volts and there is some 45 volts p-p drive (made up of 39 volts p-p from winding 13-14 and 6 volts p-p from C707 via V702a. Approximately 380 volts p-p will be across T701 primary, but V701 anode will be about 450 volts p-p with respect to earth due to the imperfect decoupling provided by C702.

R718 and C711 are included to allow Z modulation facilities to be available both for internal and external use. R719 in conjunction with transformer winding strays has a sufficiently short time constant, compared with C712 and R720, to produce negligible distortion of the bright-up pulse.

C707 in series with R726 is included to stop the feedback system from squegging at certain load levels. Filter R704 and C703 is included to reduce e.h.t. voltage transients on the +100 volt line; this safeguards against possible Y breakthrough.

3.10.2 (continued)

In the event of the e.h.t. transformer being dismantled for any reason it is most important that the air gaps (0.005"), included in both outside limbs of the core, should be accurately matched. Uneven flux distribution, due to unequal gaps, could cause wide variations of heater voltage on the QU37 rectifiers. The heaters are run at a nominal 1.2 volts r.m.s. (20 kc/s).

3.10.2.1 Cathode-Ray Tube Operating Conditions The regulation of the c.r.t. cathode voltage is such that, from cut off to maximum brightness, the voltage on pin 2 of the c.r.t. varies by less than 1%. The uncontrolled +10 kV output should vary by less than 5% for the same change in conditions.

The c.r.t. is run with a p.d.a. ratio of 8.3, which, according to the c.r.t. manufacturer gives a range of sensitivities as follows :-

X plates : 16.5 -20.5 V/cm
(Mean 18.5 V/cm)

Y plates : 3.2 - 4.6 V/cm
(Mean 3.9 V/cm)

The range of the FOCUS control (-750 volts to -950 volts) and that of the geometry preset (+175 volts to +350 volts) is adequate to satisfy the c.r.t. manufacturer's stated range for 'limit' tubes. To satisfy the requirements for the ASTIG control range, a potentiometer network is connected between the unregulated + 500-volt supply and the +350-volt line giving a coverage of +250 volts to +390 volts.

The ±50 volt range of the BRILLIANCE control is adequate to cover all c.r.t. grid bases and circuit tolerances without the need for a preset control.

The mean Y-plate potential is +320 volts.

The mean X-plate potential is +260 volts.

The i.p.s. (inter-plate shield) potential is fixed at the mean Y-plate potential of +320 volts by resistors R721 and R725.

3.11 POWER SUPPLY (Circuit Diagram XD 37338)

3.11.1 Synopsis

Transformer T801 feeds five bridge rectifiers to produce, via conventional series regulators and control amplifiers, five fully regulated supplies at +350 volts, +250 volts, +100 volts, -150 volts and -6.3 volts.

Delay relay RL800, timed by V804, witholds the h.t. potentials from the instrument until sufficient time has elapsed for all the valves to have warmed up. R809 is included so that the contacts of V804 are nearly closed when the instrument is on, thus reducing the waiting time if the supply is momentarily disconnected.

The -150 volt is set by RV802 which indirectly sets the +100, +250, and +350 volt lines. The -6.3 volt line is set by RV801. A calibration circuit producing an accurate 0.5-volt p-p trapezoidal waveform at low impedance for calibrating the Y amplifier gain, is also situated in the power supply unit. Adjustment of the calibration voltage is by means of RV803.

3.11.2 Circuit Analysis

3.11.2.1 -150 volt line

HT4 produces the drive voltage for full-wave bridge rectifier MR817-20. Series regulation is provided by V803 shunted by R825 and R826 to reduce the valve dissipation to permissible limits. R818 and R819 tend to equalize the anode currents in the two halves of V803.

The correction amplifier consists of V810a and V810b as a long-tailed pair, V809b as a grounded-grid amplifier and, finally, V809a as an output cathode follower. The operation of the control amplifier is as follows :-

3.11.2.1 (continued)

The grid of V810b is held constant at -85 volts by neon reference tube V813 (maintained by R870), while the grid of V801a is free to move in the same sense as the -150 volt line. Fast changes meet with negligible attenuation via C808, while slow changes are attenuated by the voltage-dividing action of R850, RV802 and RV849. This signal loss is minimized by R849 having a high value and being returned to the +85 volt stabilizer V812.

A negative-going error on the -150 volt line causes the grid of V810a to go negative and the cathodes of both halves of V810 follow the grid negative. Since the grid of V810b is held at a constant potential, this valve is driven by its cathode and the anode will go in a negative direction. The signal is further amplified by grounded-grid stage V809b and then fed through a cathode follower V809a whose cathode will go in a negative direction. The cathode of V809a is coupled to the grid of series regulator valve V803 via a potential divider network using V805 and V806. This potential divider reduces the standing d.c. to a suitable value for the grid of V803 while introducing negligible attenuation of the error signal. Series regulator, V803 is thus biased with its grids more negative than before, so as to restore the output voltage to its correct value.

The loop gain of this regulator circuit is about 1000, reducing the 20 volt ripple to about 20 mV. The ripple content on the line is reduced about four times further by using 'backing-off' techniques. R872 adds a little unstabilized ripple to the screen grid of V801b in the correct phase to provide further cancellation of the residual ripple. The regulation of the -150 volt line is particularly important as all the other h.t. supplies use it as a reference potential.

3.11.2.2 +100 volt line

Transformer secondary winding HT3 is full-wave rectified by the bridge, MR813-16. The smaller load current on this line enables one half of a type 6080 valve to be used as the series regulator (V802b). R823 provides a shunt path across V802b, thus reducing its anode dissipation. V807 is the control amplifier - a pentode being used because of the low anode voltage necessary to drive the grid of V802b. R843 and R845 determine the reference potential, assuming that the -150 volt line has been correctly adjusted. R824, R834 and R835 form a 'backing-off' network which reduces the h.t. line ripple to less than 10 mV.

3.11.2.3 +250 volt line

HT2 produces the drive voltage which is rectified by MR805-12 in the form of a capacitively-loaded full-wave bridge. The rectifier elements are series connected in each arm of the bridge to withstand the peak-inverse voltage. The load current on the +250 volt line is higher than that of the +100 volt line but is still not high enough to warrant the use of both halves of a type 6080 valve; two bypass resistors are included (R817, R829) to limit the valve dissipation. Because of the higher volts available, a starved cascode amplifier, V808, is used, the reference voltage being derived from the -150 volt line by R858 and R859; 'hum bucking' is achieved by R844, R851 and R852.

3.11.2.4 +350 volt line

HT1 is rectified by MR801-04 and added to the rectified output of HT2. V801 is the series regulator valve, and R820-22 are the shunt resistors. R815 and R816 tend to equalize the anode currents in the two halves of V801. A cascode amplifier, V811, obtains its reference potential from the -150 volt line by R867 and R868. R846, R862 and R863 provide the 'hum bucking' voltage.

3.11.2.5 +300 volt line

A positive 300-volt supply for the ASTIG control is also derived from rectifier MR801-804, this supply is filtered by the reservoir capacitor C804 before being reduced to 290 volts by the potential divider formed by R722 and Zener diodes MR708-9.

3.11.2.6 -6.3 volt line

LT4 drives a bridge rectifier, MR821, which is capacitively loaded by C801. Conventional series regulation is obtained from transistors VT801 and VT803 which control the series element VT802. The reference voltage is obtained from Zener diode MR822 and the -6.3 output voltage is accurately set by RV801. As the output voltage is developed immediately the instrument is switched on, it is necessary to ensure that -6.3 volts is delivered both before and after the thermal delay, V804, has operated; R810 and R811, together with contacts RL800b, are included for this purpose. The resultant output is an accurate 6.3 volts under all conditions with only a few millivolts of ripple.

3.11.2.7 L.T. Supplies

Centre-tapped winding LT1 supplies 8.0 volts to thermal delay switch V804 and its associated relay RL800. These components prevent h.t. being applied before the valves have had sufficient time to warm up. Interlock contacts using pins 22 and 23 of socket SKA cause the h.t. to be switched off when the plug-in pre-amplifier unit is withdrawn. LT1 is also used to provide a switching waveform for transistor VT804 in the CAL waveform generator.

LT2 and LT3 are biased positively by 70 and 200 volts respectively; this raises the heater potentials of the valves concerned so that the heater to cathode ratings are not exceeded.

LT4 is full-wave rectified by MR821 which develops approximately 11.5 volts across reservoir capacitor C801; the supply is then series regulated as already described - see -6.3 volt line.

LT5 provides an a.c. heater supply for the cathode ray tube and is maintained at the same potential as the c.r.t. cathode.

3.11.2.8 CAL waveform generator

The base of VT804 is driven via R847 from a part of LT1 winding (about 6 volts p-p). R873 biases the base so as to achieve a 50/50 mark/space switching ratio from the sinusoidal input, the transistor being alternately bottomed and cut off. This alternately shorts and open-circuits the junction of R853 and R854, changing the potential at this point from -18 volts to zero.

The maximum error in the short-circuited condition is 20 mV in 20 volts (0.1%), and the maximum error in the open-circuited condition is 2 μA in 2 mA (0.1%) giving a total possible error of 0.2%. Once the output voltage has been set for 0.50 volt at the junction of R854 and R857, the CAL voltage normally remains correct to within ±0.1% provided the -150 volt line remains constant.

3.11.2.9 Thermal Cut-out

A thermal cut-out, S802, in the mains input circuit is designed to prevent overheating of the oscilloscope. Should the temperature inside the instrument exceed approximately 57°C the cut-out will open and switch off the mains supply. When the temperature falls to a safe level, the supply is automatically reconnected. In particularly hot climates it may be necessary to reset the cut-out manually, using an insulated probe.

3.11.2.10 Miscellaneous details

The resistor network R804 to R807, associated with HT2 series-connected diode rectifiers, is included to ensure equal voltage sharing across the rectifiers when they are in their non-conducting state.

R812, R813, and R814 are fitted instead of bleeder resistors to discharge the reservoir capacitors via the load of the oscilloscope circuits in the event of a fuse blowing. This eliminates the use of high-wattage resistors as permanently connected bleeds. The 350-volt line makes use of relay contacts RL800a and resistor R808 to discharge C804.

C805 is a parasitic stopper and its function should not be confused with that of C808, C809, C807 and C810 which are a.c. feed capacitors for the other voltage-regulator amplifiers.

3.12 SWITCH ATTENUATOR (Circuit Diagram XD 34658)

3.12.1 Synopsis

The Switch Attenuator is common to all the Plug-In Units and, for this reason, it is described separately. The design is based upon the following considerations :-

(1) Stray capacitance is reduced to a minimum.

(2) Unused attenuator elements are shorted to earth.

(3) Input resistance is 1 MΩ on all ranges.

3.12.1 (continued)

(4) All attenuator sections match into 1 MΩ.

(5) Input capacity does not exceed 30 pF on any range.

Five sections have attenuations of ÷2, ÷4, ÷10, ÷10 and ÷100 are used, one, or at the most two, of these sections are operative at any one time, as shown in the table below :-

VOLTS RANGE setting	Input divided by :-	Sections used	
0.05	1	'straight through'	
0.1	2	÷2	
0.2	4	÷4	
0.5	10	÷10	
1	20	÷2	÷10
2	40	÷4	÷10
5	100	÷10	÷10
10	200	÷2	÷100
20	400	÷4	÷100
50	1000	÷10	÷100
CAL } CAL }	Input open circuit, attenuators earthed, and CAL signal connected to cathode follower.		

Typical performance figures for the Switch Attenuator, when correctly adjusted, are as follows :-

±2% at frequencies up to 15 Mc/s on all ranges.
±2% at 30 Mc/s on 0.05, 0.1, 0.2, and 0.5 V ranges.
±10% at 30 Mc/s on 1, 2, and 5 V ranges.
±30% at 30 Mc/s on 10, 20 and 50 V ranges.

3.12.2 Circuit Analysis

Drawing No. XD 38472 shows the components used in each of the VOLTS RANGE switch positions. The approximate settings of the preset capacitors are shown in brackets, and these are based on the values of stray capacitance indicated on the diagram.

3.12.2 (continued)

0.05 V range

The mechanical design of the switch rotors and contacts keep stray capacity to a minimum on this range. R2 in parallel with C4 acts as an 'all pass' network, but protects the input cathode follower in the event of severe overloads. Trimmer capacitor C1 adjusts the input capacity to be the same as on the 0.1 V range (all the ranges are adjusted with reference to the 0.1 V range). R9 is left in circuit but is short-circuited for reasons of switching simplicity.

0.1 V range

This range is used as a reference for input capacity adjustment of the other ranges. C5 has a tolerance of ±0.5 pF and C9 is adjusted to make the capacitive pot-down ratio exactly 2:1, so that the input capacitance of the pot-down section is 11 pF ±0.25 pF. The total input capacitance is therefore 14 pF (strays) 2.2 pF ±0.5 pF (C2) and 11 pF ±0.25 pF (pot-down section). The total variation of input capacitance is ±0.75 pF with an additional ±1 pF for variations of strays. R3 and R6 are of such values that, in conjunction with R9, they function as a ÷2 attenuator and have an input resistance of 1 MΩ.

R2 and C4 are switched out of circuit on this, and all subsequent ranges - the pot-down components themselves afford adequate protection.

0.2 V range

Trimmer capacitor C11 enables the capacitive pot-down ratio to be set to exactly 4:1, after which C8 is set to match the input capacity to that of the 0.1 V range. R4 and R7 are of such values that, in conjunction with R9, they function as a ÷4 attenuator and have an input resistance of 1 MΩ.

0.5 V range

Trimmer capacitor C12, padded by C13, enables the capacitive pot-down ratio to be set to exactly 10:1, after which C3 is set to match the input capacity of the 0.1 V range. R5 and R8 are of such values that, in conjunction with R9, they function as a ÷10 attenuator and have an input resistance of 1 MΩ.

3.12.2 (continued)

1 V, 2 V, and 5 V ranges

These ranges use the 0.1, 0.2 and 0.5 volt sections cascaded with a ÷10 section consisting of C15, C18, C19, C20, R11, and R12 (shunted by R9). Trimmer capacitor C19 enables the capacitive pot-down ratio to be set to exactly 10:1, after which C15 is set to make the input capacity of the ÷10 section the same as that of the cathode-follower valve. Again, this section has an input resistance of 1 MΩ, thus correctly loading the preceding section.

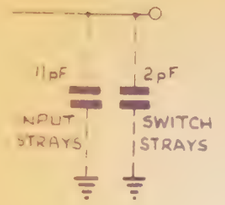
10 V, 20 V, and 50 V ranges

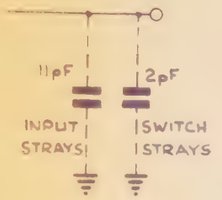
Here the ÷10 section is replaced by a ÷100 section comprising C14, C16, C17, C21, R10, and R13 (shunted by R9). The capacitive pot-down trimmer cannot be connected in the earthy arm as the value would be prohibitively large. Instead, it is connected across the top arm, in series with C17 to reduce its coverage. C14 sets the input capacity of the ÷100 section to be the same as that of the cathode-follower valve and ensures correct loading of the previous section.

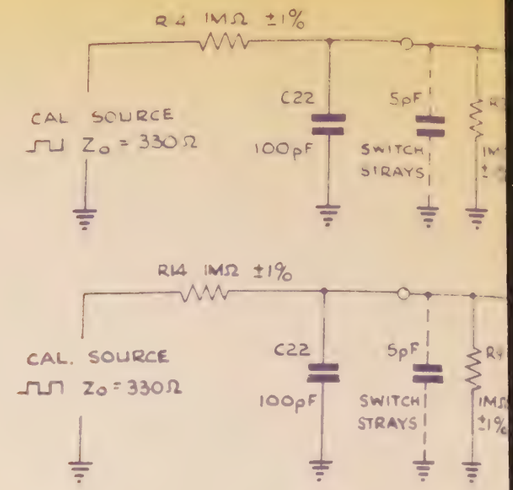
Despite every design precaution, the stray inductance associated with capacitor C21 produces a resonance at about 300 Mc/s and on the top three ranges only, this would have a serious effect on the display of pulses with very fast rise times. Resistor R15, in conjunction with the valve input strays forms a low-pass filter to counteract this effect; this attenuates a 30-Mc/s signal by about 0.5 dB but greatly improves the shape of fast-pulse displays.

CAL positions

In the CAL positions the input is open-circuited and isolated from the cathode follower. In its place a 0.5 volt p-p trapezoidal calibration waveform is connected via R14 and R9 which form a ÷2 section; this produces the desired 250 mV p-p testing waveform at the grid of the amplifier. When the CAL waveform is not required, the junction of R14 and C22 is disconnected from R9 and shorted to earth; this ensures no breakthrough to the high impedance grid circuit. In this condition R14 is shunted across the CAL generator output; the loading of 1 MΩ has no significant effect upon the CAL waveform (which might be required for the other channel of the Dual Trace Unit) due to the low source impedance of the generator, approximately 330 Ω. C22 is included to decouple a small amount of e.h.t. (20 kc/s) breakthrough and renders it invisible on the screen. The rise time of the supply-frequency trapezoid is about 30-40 μsec.



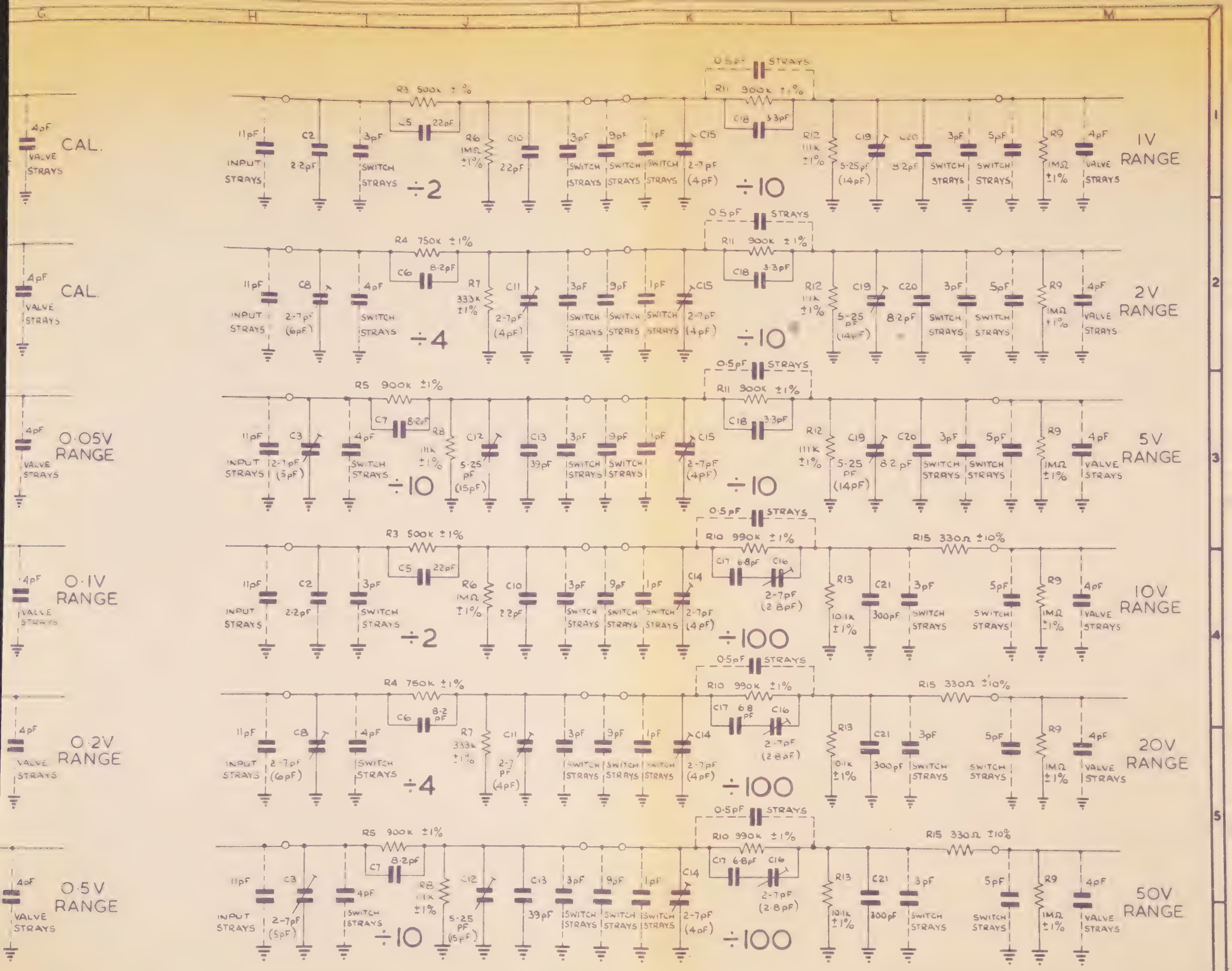




TITLE

ANALYSIS OF SWITCH ATTENUATOR RANGES

DRAWN	DATE	CHKD.	APPD.	TRC'D.	ASSEMBLY	STOCK LIST	DRAWING NUMBER
J.K.M.	4-4-62	[illegible]				TF2200	XD38472
MARCONI INSTRUMENTS LTD.							SHEET 1 OF 1 SHEETS



ANALYSIS OF SWITCH ATTENUATOR RANGES – TF2200

XD38472

4 MAINTENANCE

4.1 GENERAL

It is strongly recommended that you should become familiar with the principles described in Section 3 - TECHNICAL DESCRIPTION - before commencing with the adjustment or replacement of component parts of the instrument. The Circuit Diagrams and Component Lists show all the electrical components contained in the oscilloscope, together with their values and significant ratings.

In case of difficulties, or for general advice on servicing your instrument, do not hesitate to write or telephone our Service Department or nearest Area Office. Always mention the type number and serial number of your instrument. (For addresses and telephone numbers, see the rear of this handbook.)

4.2 CLEANING THE AIR FILTER

The air intake to the ventilating fan is protected by a plastic filter attached to the rear of the oscilloscope by means of quick-release fasteners.

No firm rule can be made regarding the frequency of cleaning - the filter will need frequent cleaning if the instrument is operated in a dust-laden atmosphere - once every six months may be sufficient in the average laboratory.

Electrostatic attraction enables the plastic filter-unit to function satisfactorily under normal air conditions; when operating the oscilloscope in a particularly humid environment, it will be found that improved filtration is achieved by lightly oiling the plastic element; when used in this way, more frequent cleaning will be found necessary.

If at any time the filter should become completely choked with dirt, thereby causing the oscilloscope to overheat, a thermal cut-out will operate, switching off the mains supply (see Section 3.11.2.9).

4.2 (continued)

Cleaning instructions for both ways of using the filter are set out below :-

Filter - Dry

(a) Remove the filter unit from the oscilloscope by depressing the chromium-plated domes at the top of the filter. Hinge the filter downwards to disengage the metal tongues at its lower edge.

(b) Knock the filter unit against the edge of the bench to dislodge the dust, and blow out any remaining dust particles with a compressed air line before re-fitting.

Alternatively :

(c) Clean in warm soapy water to remove all the dust and dirt. The temperature of the liquid must not exceed 50°C (120°F).

(d) Shake out the excess moisture and allow a few minutes for the filter to dry before re-fitting.

Filter - oiled

(a) Remove the filter and immerse in a 5% solution (by weight) of Teepol and water and agitate it so that the liquid passes through the element in both directions. The temperature of the liquid must not exceed 50°C (120°F).

(b) Dry the unit throughly.

(c) Spray the filter lightly on both sides with a 50/50 solution of medicinal paraffin (mineral oil) thinned by benzene or preferably xylene. (Alternatively, spray with Mio-Oil 101, obtainable from Mica and Micanite Supplies Ltd., Barnsbury Square, London, N.1.)

(d) Allow time for the inflammable vapour of the solvent to evaporate completely before replacing the filter unit.

4.2 (continued)

CAUTION : Do not employ a steam jet, hot liquids, or chlorinated solutions (e.g., Trichlorethylene, etc.) for cleaning, as these can damage the filter.

4.3 REMOVAL OF COVERS - ACCESS TO COMPONENTS

To remove the covers and gain access to the interior of the oscilloscope, release the four Oddie fasteners securing the top cover - a quarter turn with a screwdriver unlocks them - lift the cover clear of the instrument. This leaves the side panels ready for removal and these should be lifted away from the instrument.

To gain access to the underside of the oscilloscope turn it upside down, and release the four Oddie fasteners securing the bottom cover.

4.3.1 Time Base Removal

In order to gain access to certain components in the time base, it is necessary to remove the right-hand part of the front panel complete with the printed wiring boards attached to it. This is greatly simplified by the use of plug-in construction, and the unit should be removed as follows :-

(1) DISCONNECT THE MAINS LEAD FROM THE SUPPLY OUTLET. EVEN WITH THE OSCILLOSCOPE SWITCHED OFF, LIVE MAINS CONTACTS WILL BE EXPOSED DURING THIS PROCEDURE.

(2) Remove the four Philips head screws securing the time base panel. Two screws at the top and two at the bottom.

(3) Remove the screw securing the rear of the Delaying Time Base board - the top board in the assembly.

(4) Remove the two screws securing the rear of the main time base wiring board - the second board down from the top.

(5) Remove the screws securing the time base unit at its inner side - one screw at the top and one at the bottom.

4.3.1 (continued)

(6) Unplug the bright-up lead from the socket on the inner surface of the time base unit. This wander plug connection is accessible from the left-hand side of the instrument.

(7) Unplug the red and black X amplifier output connections at the rear of the unit.

The time base assembly may now be slid out of the front of the oscilloscope. Replacement is the reverse of the above procedure.

A screening partition is fitted to the inner surface of the time base to give access to the inner side of the FUNCTION, RANGE, and TRIGGER MODE switches. This is secured by two screws at its top edge. The partition may be removed with the time base in situ, when the plug-in pre-amplifier unit is being operated at the end of the Extension Cable, TM 6943.

4.3.2 E.H.T. Unit Removal

To service the E.H.T. Unit, first remove the top and side covers from the oscilloscope, as described in Section 4.3, then remove the red screening cover from the E.H.T. Unit by extracting two screws. This gives reasonable access to the valves, e.h.t. transformer etc. The underside of the printed board is protected by a louvered cover secured by two screws.

If it is necessary to remove the entire printed board, detach the rear panel of the oscilloscope, as described in Section 4.3.3 below. Unsolder the wires to terminals 7-12 and 18-23 inclusive, unsolder the final anode connection from R714, remove the seven nuts securing the printed board to its mounting pillars, and lift the wiring board out through the rear of the oscilloscope.

4.3.3 Rear Panel Removal

When replacing the transistors, servicing the relay, etc. it is necessary to remove the rear panel complete with cooling fan and motor. Remove eight Philips head 4 BA screws, and lift the panel

4.3.3 (continued)

away from the oscilloscope. The supply to the fan motor is via a small 2-pin plug and socket; remove this plug to separate the panel from the oscilloscope - the panel remains threaded on the supply lead unless the mains plug is removed.

4.4 REPLACEMENT OF FUSES

The TF 2200 contains seven fuses. The mains input circuit is protected by two fuses of 5 ampere rating (FS801 and FS802) which are connected in series with the supply input leads to the primary of mains transformer, T801. These supply fuses should be replaced with 10 ampere cartridges if the oscilloscope is to be operated from 100 to 130 volt mains.

Four fuses of 500 mA rating protect the h.t. secondary circuits of the mains transformer (FS803 to FS806), while a single 5 ampere fuse (FS807) protects the -6.3 V regulated supply.

To gain access to the fuses, remove the top and side covers as described in Section 4.3; the supply mains fuses are mounted in clip holders beneath the neck of the cathode ray tube at the left-hand side of the oscilloscope. All the remaining fuses are located alongside the mains transformer at the right-hand side.

The fuses are of glass cartridge type, and should be replaced with standard Size 0 (1 1/4" x 1/4") fuse links - Belling-Lee Type L1358, L1055, or equivalent.

4.5 MAINS INPUT ADJUSTMENTS

The oscilloscope is normally supplied ready for immediate operation with 240 V (50 to 60 c/s supplies). It may, however, be adjusted to operate from any 50 to 60 c/s supply in the ranges 100 to 130 and 200 to 250 volts.

4.5 (continued)

Mains input adjustments are made by means of four two-pin plugs which make contact with the connections to the transformer through a reversible masking plate. This plate is marked on one side with the voltages applicable to the 200 to 250 V range (white figures), and on the reverse with voltages applicable to the 100 to 130 V range (black figures). All the possible combinations to suit the input ranges covered by the instrument are shown overleaf.

To check, or alter, the mains tappings, remove the covers as described in Section 4.3 - the tapping panel is located below the neck of the cathode ray tube on the left-hand side of the instrument. When changing from one major voltage range to the other and reversing the masking plate, see Section 4.4 regarding altered fuse ratings.

4.6 WORKING VOLTAGES

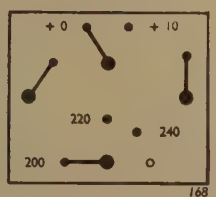
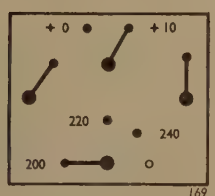
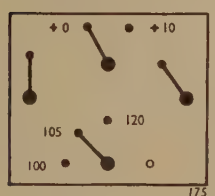
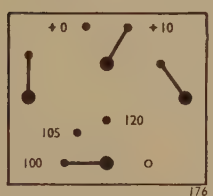
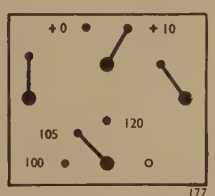
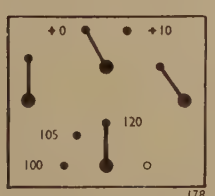
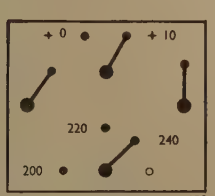
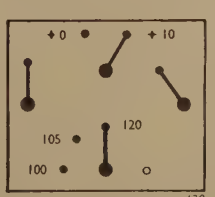
The static voltages and waveforms appropriate to certain parts of the circuit are given on the Circuit Diagrams in Vol. II of this handbook. All measurements were taken with the oscilloscope functioning normally, by means of a 20,000 ohms/volt meter, e.g. Avometer, Model 8.

Unless otherwise stated, all voltages other than those across transformer windings are taken with respect to chassis. It should be noted, however, that transformer windings LT2 and LT3 are raised to positive potentials of 70 and 200 volts respectively, so that the valve heater/cathode ratings are not exceeded. LT5 is maintained at the same potential as the c.r.t. cathode.

On individual oscilloscopes, some differences in voltage readings may be expected due to normal variations of valve and transistor performance and the tolerance of associated components. Before making any measurements, adjust the supply voltage plugs to agree as closely as possible with the actual supply voltage (see Section 4.5).

SUPPLY VOLTAGE PANEL

Masking plate and links must be positioned according to supply voltage, as shown:—

200-250 volts a.c. SUPPLY	LINKS		LINKS	100-130 volts a.c. SUPPLY
200 V	 168		174	100 V
210 V	 169		 175	105 V
220 V	170	To change voltage range, remove all links and reverse masking plate	 176	110 V
230 V	171		 177	115 V
240 V	172		 178	120 V
250 V	 173		 179	130 V

SUPPLY VOLTAGE PLUG SETTINGS

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4.7 WIRING COLOUR CODE

To simplify manufacture and subsequent servicing of the TF 2200, the various supply leads are colour-coded to assist rapid identification. This colour coding must not be regarded as mandatory, and is governed by the availability of suitably coloured wire at the time of manufacture. In general, however, your instrument will conform to the following code.

Insulation Colour	Function
Red/Blue	+350 volt supply
Red/Green	+250 volt supply
Red/Orange	+100 volt supply
Red	+85 volt supply
Black	Earth
Brown/White	-6.3 volt supply
Violet/Yellow	-85 volt supply
Violet	-150 volt supply
Brown	Heater Supply
Blue	Anode connection
Yellow	Cathode connection
Green	Control Grid connection
Orange	Screen Grid connection
Grey	Suppressor Grid connection

When a supply lead is taken direct to a valve electrode, the supply lead colour takes preference - e.g. If the +250 volt line is taken direct to the screen grid of a pentode valve, the wire will be Red/Green and not Orange.

Two-colour wires consisting of a main body colour with a narrow tracer may have the colours in either combination - e.g. Red/Orange could be predominantly Red with an Orange tracer, or predominantly Orange with a Red tracer.

4.8 REPLACEMENT OF C.R.T. VALVES & SEMICONDUCTORS

4.8.1 C.R.T. Removal and Adjustment

WARNING : Before touching the cathode ray tube or any associated components, great care must be taken to ensure that ALL e.h.t. points are carefully and efficiently discharged to chassis. A well insulated earthing lead should be used for this purpose.

After discharging the c.r.t. connections in this way, it is still possible for a charge to build up again, due to the gradual release of dielectric charge in the glass of the tube. As a final precaution, discharge the electrodes a second time immediately before the tube is removed from the oscilloscope.

The cathode ray tube can be removed from the oscilloscope, without disturbing the mu-metal shield, as follows :-

(1) Hinge back the viewing hood and lift it off its pintles, complete with graticule and filter, as described in Section 2.5.1.

(2) Remove the top and side covers as described in Section 4.3, and the rear panel as described in Section 4.3.3.

(3) Uncouple the final anode connection and all the side-connections to the deflection plates etc.

(4) While supporting the screen-end of the tube, apply gentle pressure by pushing from the base-end until the pins disengage from the base connector. The tube will now slide out of the front of the oscilloscope.

Replacement is the reverse of the above procedure except that care should be taken to ensure that the tube neck is inserted through the loop of the adjusting strap inside the mu-metal shield. This strap enables the tube to be rotated around its longitudinal axis to obtain a horizontal trace. Before using the strap to adjust the tube in this manner, first slacken the nuts on the tube base connector so that the base is free to rotate with the tube.

4.8.1 (continued)

Movement of the leads between the delay line and the Y-plate pins will affect the performance of the delay line on fast pulses. To restore the pulse performance to optimum, display a fast pulse with a risetime of less than 3 nsec and note the reflection on the waveform following the pulse by approximately 0.4 μsec. Adjust the distance between the wires to obtain minimum reflection.

4.8.2 Valve Replacement

A list of valves fitted, together with suitable alternative types, will be found in the SCHEDULE OF PARTS SUPPLIED section at the beginning of this handbook. It is recommended that faulty valves should preferably be replaced with the type originally supplied with the instrument. In general, most valves may be replaced without special selection or aging, although in certain cases replacement may necessitate some readjustment of associated preset components as discussed in Section 4.9. Balanced pairs of valves are used for the final stage of each plug-in Y pre-amplifier, and also for the input stage of the main Y Amplifier (V101 and V102). In the event of one of these valves requiring replacement, it is normally necessary to obtain a matched pair to ensure that the associated BALANCE preset can be correctly adjusted.

The reference number of each valve (or an abbreviated number) is marked on the printed board alongside each valve holder. Where space permits, the full valve reference is given, e.g., V602, V401, etc. In other instances, where space is not available for the full reference number, an abbreviation is used, e.g., V7 instead of V507. Although this means that a particular valve number, V1 for instance, appears on a number of boards, it is a simple matter to identify the board concerned and to deduce that V1 is an abbreviation of, say, V501.

With the covers removed from the instrument, all valves, apart from those in the e.h.t. unit, are readily accessible. To gain access to the valves inside the e.h.t. unit, the screening cover surrounding this section must be removed as described in Section 4.3.2. The two QU37 rectifying diodes, V703 and V704, inside the unit are soldered to tags on the printed wiring board. When replacing these valves, particular care should be taken not to damage the metal-to-glass seals, either by mechanical strain or by excessive heat.

4.8.3 Replacement of Transistors

The necessity for transistor replacement is unlikely and, should such an event occur, the transistor failure can usually, be attributed to component break down in the associated circuit.

With the bottom cover and rear panel removed from the oscilloscope, all the transistors will be found mounted on the power unit chassis at the rear of the oscilloscope. VT803 and VT804 are held in metal holders while VT801 and VT802 are mounted on the chassis.

Special selection of replacement transistors is unnecessary, but adjustment of associated preset controls should be expected. Full details of preset adjustments are given in Section 4.9.

Great care should be exercised to avoid overheating the replacement transistor - each joint being made as rapidly as possible. The use of a thermal shunt between the transistor and the soldering iron is strongly recommended.

To replace VT801 or VT802, unsolder the emitter and base connections, unscrew the nuts securing the transistor to the chassis, and remove the transistor complete with insulating washers and mica spacer. Reverse the procedure when fitting the replacement, lightly smearing both surfaces of the mica spacer with MS4 silicone grease (Midland Silicones Ltd.) before assembly.

4.8.4 Replacement of Semiconductor Diodes

Replacement of certain of the semiconductor diodes will necessitate readjustment of associated preset controls; see Section 4.9. Special selection of the diodes is unnecessary, provided they are of identical type number to those originally fitted.

APPENDIX 2

RECOMMENDED METHODS OF SERVICING PRINTED WIRING BOARDS

Printed wiring boards are made of a laminated material with a thin sheet of copper bonded to one side. The conductor pattern is formed by an etching process. Component leads are threaded through holes punched in the boards and the ends of the leads are normally bent over against ' pads ' on the copper conductors. The completed assembly is then soldered and a protective coating applied.

Tools and Materials Required for Servicing

(1) A small soldering-iron with a bit diameter of approximately $\frac{3}{16}$" and a working temperature rather above the normal 250°C. A suitable tool is the Precision Iron, Model C240, 230–240 volts, 15 watts, with the No. 4 standard bit, made by A.N.T.E.X. Ltd., 6 Idol Lane, London, E.C.3.

(2) 22 SWG resin-cored 60/40 solder, such as Multicore Type PC35. Additional flux must not be used.

(3) A pair of small side-cutters, such as the 5½-inch Pointed Nose Diagonal Cutting Nipper, Cat. No. 21123, made by Wilkinsons Tools Ltd., Kerfoot Street, Warrington, England.

(4) A pair of small snipe-nosed instrument pliers, such as the 5½-inch or 6-inch long Snipe-Nosed Pliers, Cat. No. 23107, made by Wilkinsons Tools Ltd.

(5) A small stiff-bristled brush such as the Post Office Type Brush, fitch, Paint, No. 7, round.

(6) A small-bladed knife, e.g. a penknife.

(7) An epoxy resin repair kit, e.g. the Araldite Two-tube Pack.

Repair Procedure

It is recommended that the board be removed from the equipment before servicing, in order to facilitate inspection of the underside after repair.

Care should be taken to avoid mechanical damage to the board. Where the protective coating has been applied to both the component and the copper side of the board, it will be necessary to apply a sideways force to the component, after freeing the leads, in order to release it from the coating lacquer.

Avoid excessive heating of the joint, as this will reduce the strength of the bonding adhesive and damage more than the necessary minimum area of protective varnish.

Mechanical damage to the copper foil is most likely to be caused by stress on the component leads from the component side of the board.

In those methods where the soldering-iron is applied to the copper ' pad ', the following points should be noted:

(a) It is not necessary to remove the protective varnish beforehand.

(b) The iron should only be applied to the pad for the absolute minimum of time necessary to melt the solder.

(c) Local repair of the damaged protective coating must be carried out immediately after the final soldering and cleaning operations, to prevent the ingress of moisture.
There are three recommended methods for the replacement of defective components, the suitability of each being determined by the circumstances.

Method 1

This is the recommended method for axial lead components, and certain others, when it is possible to leave a sufficient length of wire attached to the board.

(a) Clip off the leads close to the component (Fig. 1.1). In the case of certain non-axial lead components it may be necessary to break the

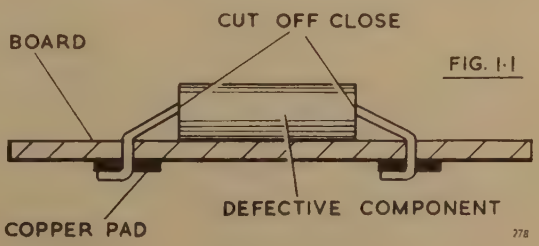


FIG. 1·1

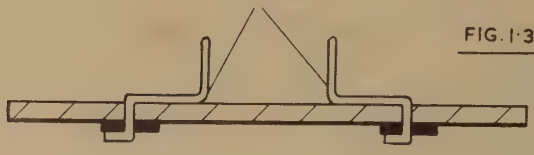
279

FIG. 1·2

280

CUT OFF

FIG. 1·3



component in the middle (Figs. 1.2 and 1.3). Remove the component.

(b) Straighten the wires left on the board, by bending away from the board, until they are perpendicular to it (Fig. 1.4).

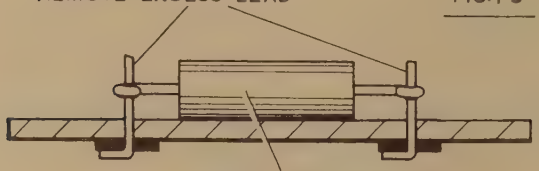
281

FIG. 1·4

(c) Bend semicircular hooks on the replacement component leads, to correspond with the spacing of the old component wires, slide on to the old leads and solder into position, ensuring that the component lies flat on the board (Figs. 1.5 and 1.6). For radial lead components, form the leads as Fig. 1.7 and attach as shown in Fig. 1.8.

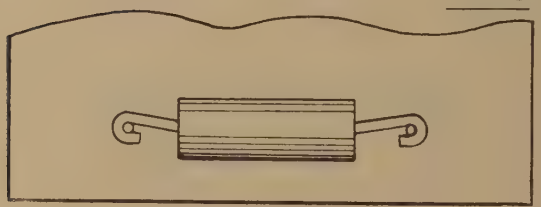
REMOVE EXCESS LEAD

FIG. 1·5



282

FIG. 1·6



283

284

FIG. 1·7

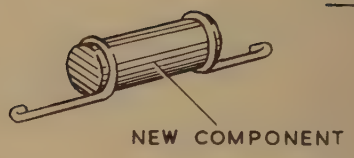
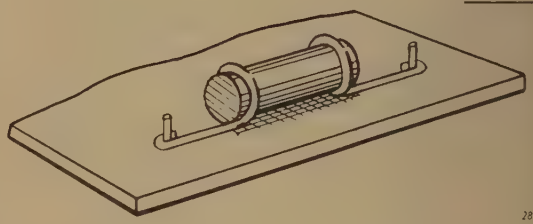


FIG. 1·8

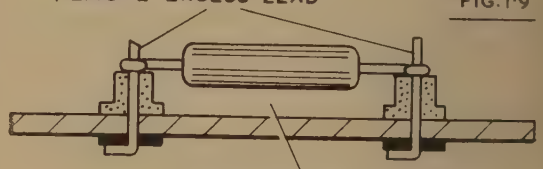


285

Note: *Where insulating spacers have been used to keep a component, such as a wirewound resistor, raised from the board, they should be retained as shown in Fig. 1.9 to maintain adequate ventilation.*

REMOVE EXCESS LEAD

FIG. 1·9



286

Method 2

This is the recommended procedure when it is desired to retain, as far as possible, the original appearance of the board. It is preferable, however, that it should not be used unless the importance of appearance overrides the obvious advantage of avoiding application of heat direct to the copper pads.

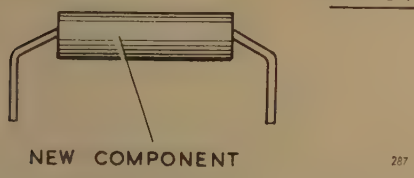
(a) Proceed as in Method 1 until the old component leads are perpendicular to the boards.

(b) Clip off the leads close to the component side of the board.

(c) Melt the soldered connection by the brief application of a hot iron and flick the board rapidly so that the lead stub is ejected, together with the solder in the hole. Check that no solder remains in the hole. Care should be taken to avoid physical damage to the board when flicking.

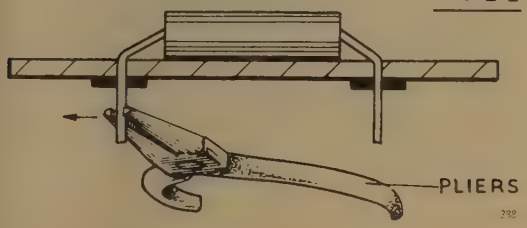
(d) Form the leads of the replacement components to the required shape (Fig. 2.1).

FIG. 2·1



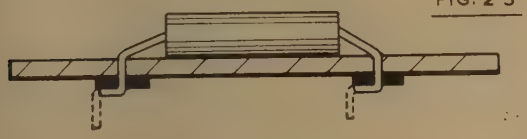
(e) Fit the component and, after ensuring that it is lying flat on the board, clench the lead ends by gripping with the pliers, $\frac{1}{8}$ inch from the board, and pressing sideways, not allowing the pliers to twist, so that the sides of both jaws remain parallel to the board throughout the movement (Fig. 2.2).

FIG. 2·2



(f) Cut off leads at the edge of the pad between the two right-angle bends (Fig. 2.3).

FIG. 2·3



(g) Resolder the joint using only resin-cored solder and a hot iron. The iron should be applied for the least possible time consistent with obtaining a good soldered joint.

Note: *Operations* **(h)** *and* **(i)** *should follow* **(g)** *as rapidly as possible. If resealing is appreciably delayed it is strongly recommended that the board be heated to 50°C and maintained at this temperature for one hour before resealing.*

(h) Remove the excess resin and any contaminant from around the joints by wiping with a degreasing solvent, e.g. trichlorethylene. Allow excess solvent to evaporate.

(i) Mix the components of the epoxy resin, according to the maker's instructions and apply to the areas from which varnish has been removed during soldering, taking care to overlap the old varnish. The new resin will cure at room temperature but, if it is desired to achieve a 'tack free' state rapidly, the cure may be accelerated by raising the temperature of the board to 50°C.

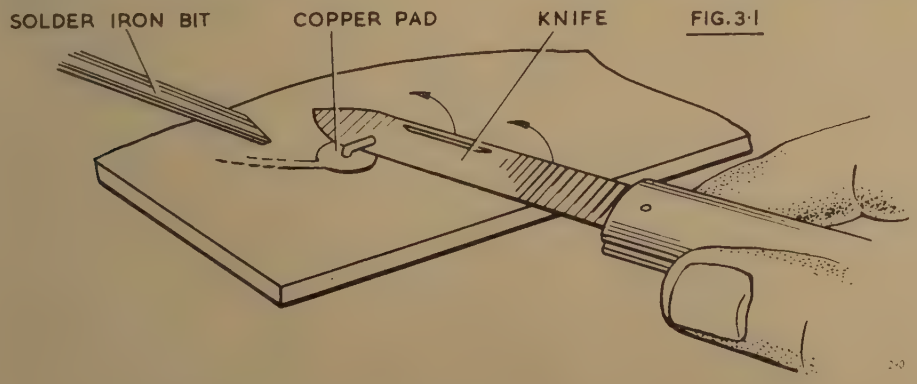
Method 3

This method is recommended where access to the leads on the component side of the board is denied and where destruction of the component to gain access is impracticable.

(a) Apply a hot iron to the soldered connections, one at a time, and as soon as the solder has melted, remove as much excess as possible with the stiff brush.

(b) With the excess solder removed, apply the soldering-iron to the clenched component lead end and, as the solder melts, introduce the blade of the small penknife under the clenched end, removing the soldering iron immediately this is achieved. Straighten the clenched end by twisting the knife in such a manner that the thin edge remains both on the board and touching the lead where it leaves the hole (Fig. 3.1).

FIG. 3·1



(c) After repeating operation **(b)** on all the leads of the component, carefully examine the leads where they enter the board, to ensure that they are not still attached to the pads. In those cases where they are attached they must be freed by reapplying the iron to the wire and, after the solder has melted, moving the wire to and fro in the hole until the solder has set.

(d) When all the leads are freed the component may be withdrawn and a new one inserted, preforming the leads where necessary.

(e) After insertion the ends are clenched, trimmed and soldered and the board resealed as in Method 2 **(h)** and **(i)**.

Note 1: *Certain components, such as valve bases, may be fitted with tags which it is impracticable to clench over because of risk of damage to the board. Where these components have to be replaced, operation* **(b)** *is omitted during the removal and, correspondingly, the re-clenching operation is not carried out when fitting the new component.*

Note 2: *In operation* **(b)** *the knife must not be inserted without first melting the solder, or damage to the copper pad may result. Similarly in* **(d)** *the component must not be withdrawn until all the leads are freed as in* **(c)**.

Test and Inspection

Note: *At no time, either while locating a faulty component or while testing following a repair, should any lead be attached to the copper side of the board.*

Repairs should be inspected for dry joints. When Methods 2 or 3 have been used the amount and shape of solder should be similar to the original connections on the board, and it should be possible to see the outline of the component leads.

Repairs should be inspected to ensure that all varnish that has come off during the servicing operations has been made good and that a sufficient overlap of varnish has been allowed to effect a complete seal.

4.9 ADJUSTMENT OF PRESET COMPONENTS

Following the original setting-up procedure during manufacture, it is unlikely that further adjustment will be required. The few exceptions to this statement are those preset controls which are intended to be used as part of the operating procedure, or, for instance, RV600, SET TV FIELD, which enables you to alter the performance to suit a particular television system.

Following valve, transistor, or semiconductor diode replacement, it is probable that certain readjustments will be necessary - these are tabulated in the following sub-sections.

4.9.4 Y Amplifier

Component Replaced	Adjustment Required
V101	RV101, RV102
V102	RV101, RV102
V103	RV101
V104	RV101, RV102
V105	RV101, RV102
V106	RV106
V107	None

4.9.4.1 Adjustment Procedure

RV101, BALANCE: To adjust RV101, invert the oscilloscope and remove the bottom cover to expose the underside of the Y amplifier chassis. RV101 is located near the corner of the chassis at its left-hand (outer) side. Short together the control grids (pins 9) of V101a and V102a. Then adjust RV101 to obtain a central trace.

RV102, PRESET GAIN: RV102 is located on the underside of the Y amplifier chassis, immediately to the rear of socket SKA. To adjust RV102, connect an external measuring oscilloscope between SKA pin 16 (or pin 20) and earth. Inject a test signal of sufficient amplitude to give a 300 mV p-p waveform at SKA; then adjust RV102 to obtain a 5 cm p-p display.

RV104 CALIBRATE: RV104 is used to calibrate the VOLTS SCALE control and is mounted, together with RV105, on a bracket at the rear of the VOLTS SCALE control. RV104 should be adjusted after RV105. Assuming that RV105 has been correctly adjusted, set RV104 in the following manner :-

(1) Switch the VOLTS SCALE sensitivity to x10.

(2) Connect a standard signal of 0.5 volts p-p ±0.5% to the Y input socket of the Plug-In Unit.

(3) Adjust RV104 until the VOLTS SCALE calibration is correct.

4.9.4.1 (continued)

RV105, BALANCE: This preset control is located, with RV104, on a bracket at the rear of the VOLTS SCALE control. Adjustment of RV105 will necessitate readjustment of RV104, so RV105 should always be adjusted first.

With the VOLTS SCALE control operative and set to 0, reverse the + - switch (S102), and adjust RV105 until no shift results.

4.9.4.2 Sync Pick-Off Adjustments

RV106: This preset control is located on the underside of the Y Amplifier chassis. To adjust RV106 set the oscilloscope controls as follows :-

FUNCTION switch to NORMAL

Main time base RANGE to 500 μsec/cm

TRIGGER MODE to AC

Feed a signal into the Y input socket of the Plug-In Unit and adjust the GAIN controls and TRIG LEVEL control to obtain a 5 mm p-p display. Adjust the Y SHIFT control to centre this display on the graticule, then set the TRIGGER MODE switch to D.C. Adjust RV106 so that triggering still occurs.

C174: This trimmer is located between RV106 and the start of the delay line, on the underside of the Y Amplifier chassis. To adjust C174 connect an external oscilloscope to the cathode (pin 8) of V201b in the Trigger Circuit (Test Point 1). Set C174 to the position giving the best pulse response on the external oscilloscope, when 1-10 kc/s square-waves are being applied to the Y input of the TF 2200.

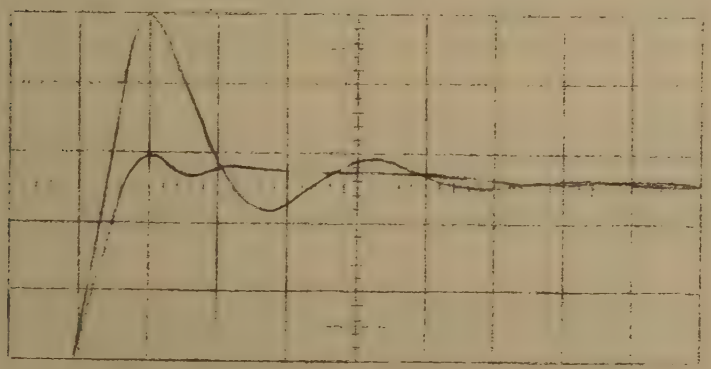
L113: L113 is mounted next to RV106 on the underside of the Y Amplifier chassis, and is normally adjusted when C174 is being set up. The external oscilloscope should remain connected to the cathode of V201b and the TF 2200 set to WIDEBAND operation. With the GAIN control set to maximum and a VOLTS RANGE setting of 0.5 volts/cm apply a 120 mV 30-Mc/s sweep signal (correctly terminated) to the input of the Plug-In Unit. Adjust L113 for best frequency response, as viewed on the auxiliary oscilloscope which must have a frequency response flat to at least 30 Mc/s.

4.9.4.3 Y Amplifier Inductors: It is unlikely that valve replacement will necessitate the readjustment of any of the inductors in the Y Amplifier circuit. If it is suspected that the adjustments have been altered, the cores may be re-set as follows :-

TRANSIENT: Inject a pulse having a risetime of 3 nsec (or better) at the grids of V101a and V102a, while still maintaining a bias of +150 volts. This will necessitate the use of a suitable external phase-splitter test rig. Adjust L103, L104, L107, L108, L111 and L112 for best pulse response without overshoot. Apply a sweep signal to V101a and V102a grids, and check that the Y Amplifier frequency response meets the following: 0 dB at d.c., -3 dB at - 31 Mc/s ±0.5 dB. These figures correspond to a calculated rise-time of 11 nsec.

WIDEBAND: Using the same test arrangement, set the oscilloscope to WIDEBAND and adjust L105 and L106 for the following Y Amplifier frequency response. 0 dB at d.c., +0.7 ±0.5 dB between 15 and 25 Mc/s, 0 dB at 30 Mc/s, -3 dB ±1.0 dB at 38 Mc/s. When adjusted in this manner, an overshoot of some 15% should be expected when viewing a test waveform with a 3 nsec rise time.

The sketch below was traced from the screen of a TF 2200 to show the difference in overshoot when the instrument is switched from TRANSIENT to WIDEBAND while displaying a squarewave with a 3 nsec rise time. The x deflection velocity was 10 nsec/cm.



4.9.4.4 Delay Line Adjustment

With the oscilloscope switched to TRANSIENT display a test waveform consisting of a squarewave with a repetition frequency not exceeding 1 Mc/s and a rise time of 3 nsec. Assuming that the rest of the Y Amplifier circuit has been correctly adjusted, examine the leading 360 nsec of the pulse for irregularities. If irregularities are present, the particular preset capacitor requiring adjustment may be determined by contacting each trimmer adjusting screw, in turn, with a small insulated screwdriver. The added capacitance of the screwdriver will cause a 'drop out' in the display and this 'drop out' may be moved along the pulse by touching the trimmers, in sequence, along the delay line.

The foregoing procedure is suitable only for minor adjustments involving the readjustment of a few trimmers. If the whole delay line requires setting up, start with all the trimmers at their mid-setting. Turn the FUNCTION switch to MULTI TRIG and display the squarewave test signal so that the amplitude of both the front and rear edge of the pulses may be compared. Adjust the delay line trimmers C113 to C169, L121 and L122, so that the tops of the displayed pulses are level and free from irregularities. This involves altering the amplitude of the first 360 nsec with respect to the amplitude of the remainder of each pulse. Note that the settings of the trimmers at the input end of the delay line are approximately equal; if they are not, it is an indication that L111 and L112 are probably set to too high a value of inductance. Should this situation arise, the inductors in the Y Amplifier should be adjusted, as described in Section 4.9.4.3, followed by adjustments to the delay line. These two adjustment procedures should be repeated alternately until the best results are obtained. The Y Amplifier inductors will, of course, affect only the first 10-12 nsec of each pulse.

4.9.5 Trigger Circuit

Component Replaced	Adjustment Required
V201	None
V202	None
V203	None
V204	None
V205	C213
MR200	None

4.9.5.1 Adjustment Procedure

C213: This is mounted on the component side of the wiring board, next to V205. To adjust C213, apply a 100 kc/s sine wave to the Y input of the Plug-In Unit, and monitor the waveform at Test Point 4 using a measuring oscilloscope. Adjust C213 until the trigger pulses have an amplitude of 11 volts. These trigger pulses may, alternately, be monitored at the following points :-

Function Circuit Board (Test Point 2): Amplitude 5 volts.

Main Time Base (Test Point 1): Amplitude 3.5 volts.

4.9.6 Delaying Time Base

Component Replaced	Adjustment Required
V301	None
V302	RV300
V303	None
V304	None
V305	RV308, RV309
V306	RV300
MR300	None
MR301	None

4.9.6.1 Adjustment Procedure

RV300, LENGTH: RV300 is located on the underside of the delaying time base board, and should be adjusted for a trace length of 10.5 cm. Adjustment of RV300 does not upset the calibration of the TIME SCALE measuring dial, or of the graticule.

RV302-RV307, RANGE RESISTORS: These six preset resistors are mounted above the DELAY TIME switch at the top of the delaying time base. To adjust the six ranges, apply suitable timing waveforms and set up each range to agree with the calibration of the TIME SCALE control.

4.9.6.1 (continued)

Delaying Time Base Range	Range Resistor
100 msec/cm	RV302
10 msec/cm	RV303
1 msec/cm	RV304
100 µsec/cm	RV305
10 µsec/cm	RV306
1 µsec/cm	RV307

RV308-RV309, MULTIPLIER ADJUSTMENT: RV308 and RV309 are mounted on a bracket at the rear of the delaying time base, and their function is to set up the minimum and maximum calibration of the DELAY TIME MULTIPLIER. Before adjusting these presets it is, of course, essential that the Delaying Time Base is correctly adjusted as described in Section 4.9.6; then proceed as follows :-

Feed a 1 msec test signal to the Y input of the Plug-In Unit and display this waveform using the delaying time base. Adjust RV308 first so that the DELAY TIME MULTIPLIER is indicating correctly when set to 1 00. Next, adjust RV309 so that the calibration is correct when the setting is 9 00. Re-set the dial to 1 00 and re-adjust RV308; continue in this manner until the calibration is correct at both points.

4.9.7 Function Circuit

Component Replaced	Adjustment Required
V401	None
MR400	None
MR401	None
MR402	None
MR403	None
MR404	None
MR405	None

4.9.8 Main Time Base

Component Replaced	Adjustment Required
V501	None
V502	None
V503	None
V504	RV500
V505	None
V506	None
V507	None
V508	RV500
MR500	None
MR501	None

4.9.8.1 Adjustment Procedure

RV500, LENGTH: RV500 is located at the upper surface of the main time base board, near the right-hand edge, and should be adjusted for a trace length of 10.5 cm. Adjustment of RV500 does not upset the calibration of the TIME SCALE measuring dial, or that of the graticule.

RV501-RV506, C524-C527: All these presets are mounted together on a board next to the main time base RANGE switch. To adjust the 24 ranges, apply suitable timing waveforms and set up the ranges underlined below to agree with the calibration of the TIME SCALE control.

Main Time Base Range (time/cm)	Range Resistor or Capacitor
2 sec, 1 sec, 500 msec	RV506
200 msec, 100 msec, 50 msec	RV505
20 msec, 10 msec, 5 msec	RV504
2 msec, 1 msec, 500 µsec	RV503
200 µsec, 100 µsec, 50 µsec	RV502
20 µsec, 10 µsec, 5 µsec	RV501
2 µsec, 1 µsec, 500 nsec	C524
200 nsec	C525
100 nsec	C526
50 nsec	C527

4.9.8.1 (continued)

The first seven preset controls adjust three ranges each. The ranges which are not underlined above should be checked for accuracy only if it is suspected that a fault condition exists. After adjustment, all the ranges should agree with the TIME SCALE control within ±2% at full scale.

4.9.9 X Amplifier

Component Replaced	Adjustment Required
V601	Possibly RV601
V602	Possibly RV601

4.9.9.1 Adjustment Procedure

RV600 SET TV FIELD: This preset control is located on the right-hand edge of the main time base board. To adjust RV600, set the oscilloscope controls as follows :-

TRIGGER MODE switch to TV

FUNCTION switch to DELAY (B)+(A)

DELAY TIME switch to 100 µsec/cm

Main RANGE switch to 10 µsec/cm

POLARITY +- switch to : + for positive-going video*
- for negative-going video*

* Assuming Plug-In Unit POLARITY switch is set to +.

Connect a correctly terminated television signal comprising field pulses (with or without video and with or without equalizing pulses) to the Y input of the oscilloscope.

Adjust the TRIGGER LEVEL control until satisfactory field sync is obtained. Rotate the SET TV FIELD (RV600) control away from its fully clockwise position until a single set of field pulses is obtained - note this setting.

4.9.9.1 (continued)

Continue rotating RV600 in a counter-clockwise direction until a dual set of field pulses appears - note this second setting. Centre the control at the mid-position between the two settings.

RV601, X SENSITIVITY: RV601 is mounted next to RV600 on the right-hand edge of the main time base board. With the oscilloscope operating from a synchronous 50 c/s supply, one cycle of the internal CAL waveform should occupy a width of 10 cm when the main time base RANGE control is set to 2 msec/cm with the EXPANSION control set to its CALIBRATED position. Adjust RV601 until this condition is met. On accurate 60 c/s supply mains, one cycle of CAL waveform should occupy a width of 8.33 cm under the same conditions.

4.9.9.2 X Amplifier Inductors

It is unlikely that valve or c.r.t. replacement will necessitate the readjustment of the two inductors in the X Amplifier circuit. If it is suspected that the adjustments have been altered, the cores may be re-set as follows :-

L601-L602: To adjust L601 and L602, connect the TB OUT terminal of an external oscilloscope to the Y input of the TF 2200. Connect a squarewave test waveform with a risetime of 30 nsec (or better) to the X IN terminal of the TF 2200, and make provision for the external oscilloscope to be triggered from this same waveform. Adjust the controls of both oscilloscopes so that the squarewaves are displayed 'on their side' on the screen of the TF 2200. Adjust L601 and L602, equally, for the best pulse response with slight overshoot; this should be approximately 5% when the EXPANSION control is set to minimum.

4.9.10 E.H.T. Unit and Display

Component Replaced	Adjustment Required
V701	None
V702	None
V703	None

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4.9.10 (continued)

Component Replaced	Adjustment Required
V704	None
V705 (c.r.t.)	RV702, see also Section 4.8.1
MR700	None
MR704	None

4.9.10.1 Adjustment Procedure

RV702, GEOMETRY: This preset resistor is mounted on the left-hand side of the oscilloscope, beneath the neck of the cathode ray tube. Feed a suitable squarewave into the Y input of the oscilloscope, and adjust RV702 for minimum barrel and pin cushion distortion.

4.9.11 Power Supply

Component Replaced	Adjustment Required
V801	None
V802	None
V803	RV802
V804	None
V805	RV802
V806	RV802
V807	None
V808	None
V809	RV802
V810	RV802
V811	None
V812	RV802
V813	RV802
VT801	RV801
VT802	RV801
VT803	RV801

4.9.11 (continued)

Component Replaced	Adjustment Required
VT804	None
MR801 to MR821	None
MR822	RV801

4.9.11.1 Adjustment Procedure

RV801, SET -6.3 VOLTS: RV801 is located beneath the mains tapping panel under the neck of the cathode ray tube. To adjust RV801, connect an accurate meter between the -6.3 V Test Point and chassis, allow the oscilloscope to warm up, and set RV801 to obtain a precise reading of -6.3 volts. The test point referred to is located at the top of the oscilloscope on the bulkhead in front of the e.h.t. unit.

RV802, SET -150 VOLTS: RV802 is located next to RV801, just in front of the fan motor. Connect an accurate meter between the -150 V Test Point and chassis, allow the oscilloscope to warm up, and set RV802 to obtain a precise reading of -150 volts.

RV803, SET 50 c/s CAL: The SET 50 c/s CAL preset control is mounted just above the mains tapping panel under the neck of the cathode ray tube. This control is set during manufacture so that 0.50 volt ±1/4% p-p appears at the junction of R854 and R857. Unless RV803 is altered it is unlikely that any change in voltage will take place unless the -150 volt line is incorrectly adjusted.

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When asking for advice always mention the type number and serial number of your instrument.

INTERCHANGEABILITY OF PLUG-IN UNITS

The plug-in units supplied with this Oscilloscope have been specially adjusted to achieve optimum performance with your particular instrument.

If these plug-in units are used with another oscilloscope or, alternatively, if other plug-in units are used with this oscilloscope, then some falling off in pulse performance may be noticed.

To adjust a plug-in unit for best performance with this instrument (a procedure that is recommended from time to time, if top performance is to be maintained) follow the instructions given in the MAINTENANCE section of this handbook :

Section 4.9.1.2 for a Single Trace Unit

Section 4.9.2.2 for a Dual Trace Unit

Section 4.9.3.2 for a TV-Differential Unit